

NATURAL RESOURCES PROGRAM

SPACE APPLICATIONS PROGRAMS

TECHNICAL LETTER NASA-37

FACILITY FORM 602	N70-41116	
	(ACCESSION NUMBER)	(THRU)
	52	1
	(PAGES)	(CODE)
	CR-77596	13
	(NASA CR OR TMX OR AD NUMBER)	(CATEGORY)

U.S. Geological Survey
Department of the Interior



UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
WASHINGTON, D.C. 20242

Technical Letter
NASA - 37
August 1966

Dr. Peter C. Badgley
Chief, Natural Resources Program
Office of Space Science and Applications
Code SAR, NASA Headquarters
Washington, D.C. 20546

Dear Peter:

Transmitted herewith are 2 copies of:

TECHNICAL LETTER NASA - 37
PRELIMINARY ULTRAVIOLET REFLECTANCE OF SOME
ROCKS AND MINERALS FROM 2000⁰Å to 3000⁰Å*

by

A.N. Thorpe, C.M. Alexander, and F.E. Senftle

Sincerely yours,

William A. Fischer
Research Coordinator
Earth Orbiter Program

*Work performed under NASA Contract No. R-146-09-020-006

~~U. S. Government Agencies Only~~

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

TECHNICAL LETTER NASA-37
PRELIMINARY ULTRAVIOLET REFLECTANCE OF SOME
ROCKS AND MINERALS FROM 2000⁰Å TO 3000⁰Å*

by

A.N. Thorpe, C.M. Alexander, and F.E. Senftle**

August 1966

These data are preliminary and should
not be quoted without permission

Prepared by the Geological Survey
for the National Aeronautics and
Space Administration (NASA)

*Work performed under NASA Contract No. R-146-09-020-006
**U.S. Geological Survey, Washington, D.C.

TABLE OF CONTENTS

	<u>Page</u>
Introduction	1
General scope of preliminary studies	
Sample preparation	
Instrumentation	
Experimental measurements	2
Results and discussion	3
Reference	4
Table I "The slope factors for various rock types..	5

DISTRIBUTION LIST

NASA Headquarters, D.C. Copies

Miss Winnie Morgan, Technical Reports Officer	2
Dr. Peter C. Badgley, Program Chief	2
Theodore A. George	1

NASA/MSC-Houston

Leo F. Childs, Chairman, Aircraft Coordination	1
Ed Zeitler, Data Center	20

Authors 10

USGS/Washington

Copies

USGS/Denver

William T. Pecora	1	Arthur B. Campbell	1
Research Coordinator	2	Robert L. Christiansen	1
Remote Sensing Evaluation and		David F. Davidson	1
Coordination Staff (RESECS)	2	Ross B. Johnson	1
Chief Geologist	1	Daniel R. Shawe	1
Associate Chief Geologist	1	Robert H. Morris	1
Assistant Chief Geologists (4)	4	Tom Hendricks	1
Chief Hydrologist	1		
Chief Topographic Engineer	1	<u>USGS/Flagstaff</u>	
Discipline Coordinators (4)	4		
Jules MacKallor	1	Geráld S. Schaber	1
William Hemphill	1		
Allen Heyl	1	<u>US Dept. of Agriculture</u>	
Robert Moxham	1		
Alan Kover	1	A.B. Park	1
David Southwick	1		
Isidore Zietz	1	<u>US Air Force</u>	
Stephen J. Gawarecki	1		
Washington Library	1	J.F. Cronin (AFCRL)	1
Denver Library	1		
Menlo Library	1	<u>US Navy</u>	

USGS/Menlo Park

A.G. Alexiou (NAVOCEANO) 1

Ernest H. Lathram	1	<u>Other Cooperating Investigators</u>	<u>Copies</u>
Hal T. Morris	1		
Robert E. Wallace	1	R.N. Colwell, Univ. Calif	1
Edward W. Wolfe	1	J. Lintz, Univ. Nevada	1
George Gryc	1	R.J.P. Lyon, Stanford Univ.	1
Max Crittenden	1	D.B. Simonett, Univ. Kansas	1
Parke Snavelly, Jr.	1	E.H.T. Whitten, Northwestern Univ.	1
		William Vest, IITRI, D.C.	1
		NAS/NRC Advisory Comm. Chm.	1

Preliminary Ultraviolet Reflectance of some Rocks and Minerals
from 2000 Å to 3000 Å

by

A. N. Thorpe, C. M. Alexander, and F. E. Senftle

INTRODUCTION

In order to appraise the concept of using the solar reflectance to determine the composition of the rocks, preliminary studies were undertaken by the U. S. Geological Survey. In the interest of speeding up the investigation, some initial measurements were made with the aid of existing equipment, both to determine the extent of the problem and also to evaluate the problems to be encountered in a more detailed study.

General scope of Preliminary Studies

About 40 specimens of rocks and minerals (including those types anticipated on the lunar surface) were selected for study. Reflectance measurements were made to see if there were any broad differences or other distinguishing features which could be used for identification purposes.

Sample preparation: The specimens were sawed into 2" X 2" X 0.5" squares. One face was cut and polished, but the degree of polish was not accurately controlled. In a few cases, slightly smaller samples were used.

Instrumentation: A 1/2 meter, grating type, McPherson spectrophotometer was used for the measurements. The grating was blazed at 1500 Å (1200 lines per mm), and the resolution was less than 1 Å between 1850 and 3050 Å. An EMI photomultiplier tube specially selected for low dark currents and high sensitivity was used. The tube also had a sodium salicylate coated window. The detector assembly was a standard

McPherson No. 650. ~~The specimen was mounted with the~~ polished face toward the entrance slit such that the angle of incidence was about 15° . Thus, polarization effects were kept to a minimum. A deuterium discharge lamp was used for a light source.

Experimental measurements: The spectrophotometer was calibrated by moving the light source directly in front of the entrance slit. The spectra recorded in this way were used to correct the sample data. The specimen was then placed in a rigid holder about 2 to 3 inches in front of the slit with the light source in the normal position. Essentially the whole surface of the sample was uniformly illuminated but due to the solid angle subtended by the entrance slit only a small portion (about 3×10 mm) of the sample was observed. Any one of these small areas was quite reproducible but due to grain size and compositional variation the spectral response would change somewhat if another small area was observed. A highly polished copper plate was subsequently run as a standard. The data of Ehrenreich and Philipp (1962) on polished copper were used to reduce the data to absolute reflectance.

Results and discussion: The corrected data are shown in the Appendix. In general the reflectance increases slightly at the shorter wavelengths and takes a sharp drop around 1900 \AA . The spectra show few pronounced peaks, and hence it is concluded that there is no significant fluorescence in the part of the spectrum measured. For comparison, see the typical fluorescence peaks shown for synthetic CsI in Figure 1.

There are a few small peaks and fine structure in some of the specimens, however, which are quite reproducible provided that the same area of the sample is observed. In part this structure may be due to a minor amount of fluorescence, but from some experiments made on a few samples, it was shown that the degree of polish seriously influences the fine structure reflectance. For valid comparison of the reflectance of rocks the degree of polish must be carefully controlled.

To attach a crude numerical value to this gradual increase in reflectance, a slope factor, M, was calculated as follows:

$$M = \frac{R_{2250} - R_{2750}}{R_{2500}}$$

where the R's are the reflectance at the specified wavelengths.

The results shown in Table 1 are not very diagnostic. All the nine granites and quartz monzonites measured had positive values whose averages were \approx 0.08 and 0.07 respectively. The three granodiorite and basic rocks measured had both positive and negative slopes. Although the average data show a trend, the data are scanty. There does not seem to be a sharp distinction in the slope of the reflectance spectrum of acid and basic rocks in this part of the ultraviolet spectrum.

The sharp attenuation of the reflectance in the neighborhood of 1900 Å is undoubtedly due to the presence of oxygen, mainly in the form of SiO₂. However, oxygen in any form, e.g., see spectrum of mica, will cause a similar drop in reflectance. It is significant

that the minerals, e.g., fluorite, which contain no oxygen, do not show this drop and in general show less fine structure throughout the range studied.

Reference

Ehrenreich, H., and Philipp, H. R., 1962, Optical Properties of Ag and Cu: Physical Review, v. 128, n. 4, p. 1922-1629.

Table 1. The slope factors for various rock types.

<u>Granites</u>		<u>Quartz Monzonites</u>		<u>Granodiorites</u>	
No. 300	0.036	No. 269	0.077	No. 315	-0.027
301	0.061	316	0.065	323	0.198
302	0.179	320	0.081	353	-0.005
303	0.146	352	0.051		
304	0.179				
305	0.066				
		<u>Basic Rocks</u>			
306	0.008	Basalt		No. 101	-0.027
307	0.024	Diabase Porphyry		No. 270	0.097
355	0.000	Gabbro		No. 308	0.052

Average Slope Factors

Granites	0.078
Quartz Monzonites	0.068
Granodiorites	0.064
Basic Rocks	0.050

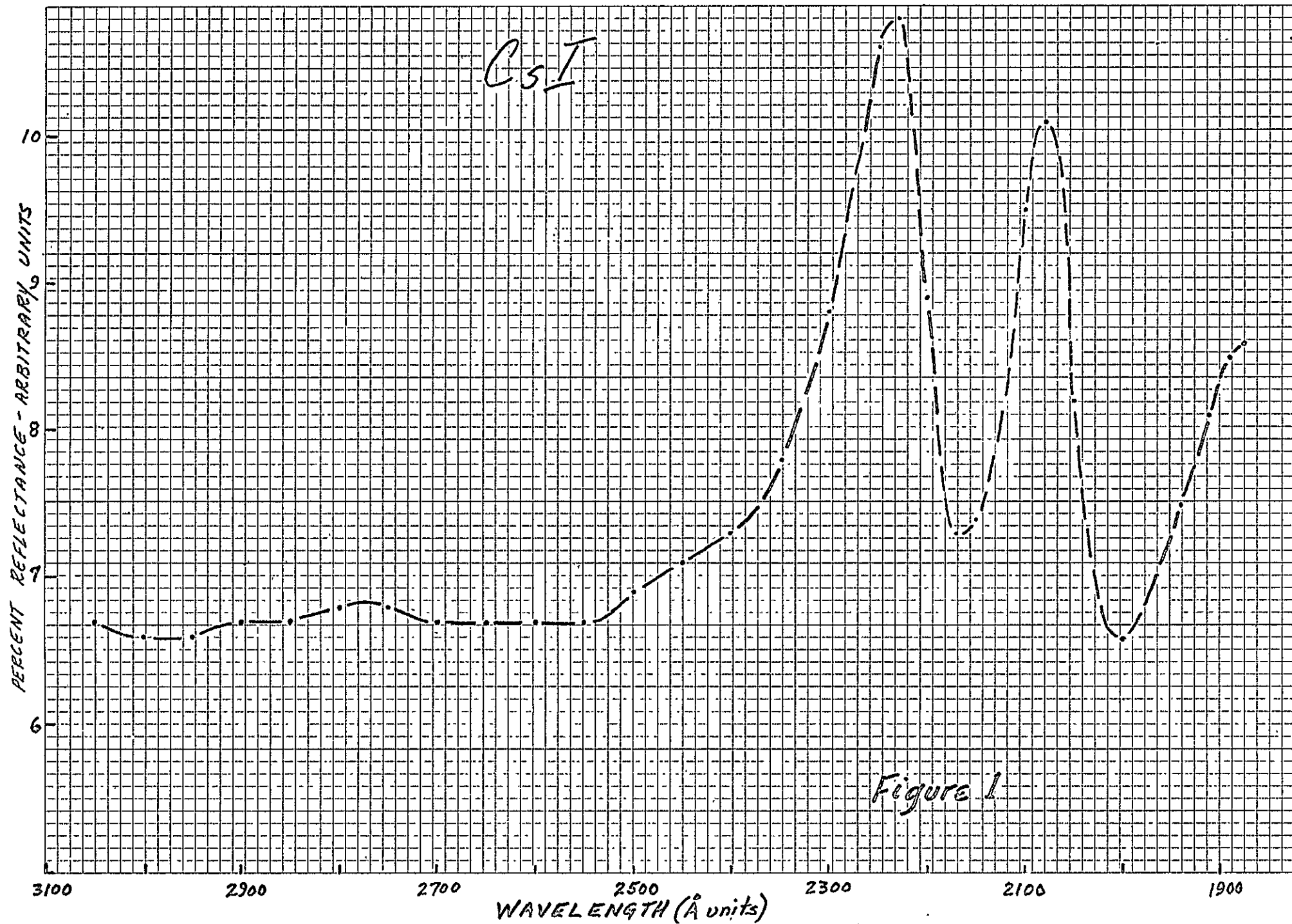
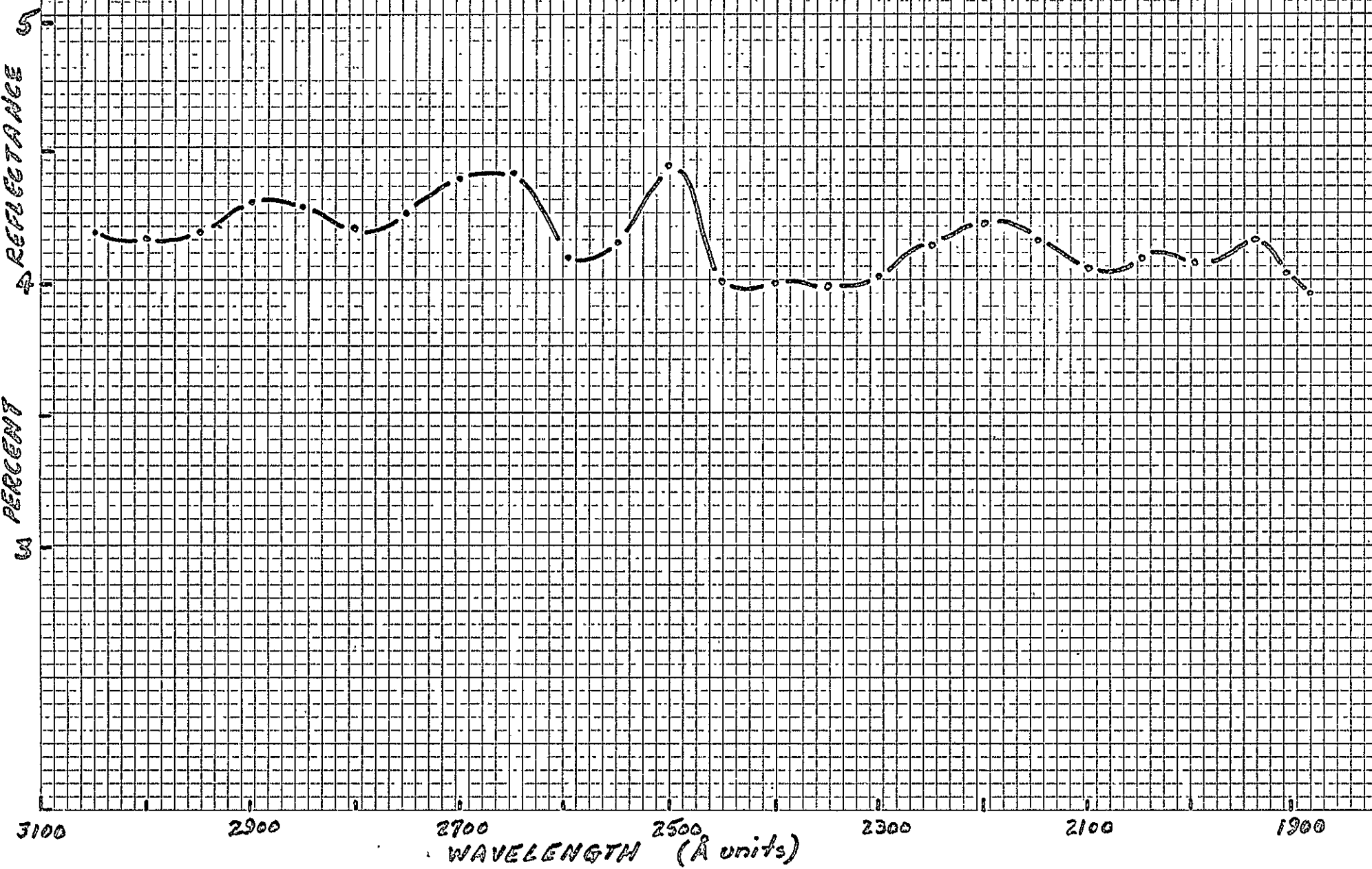


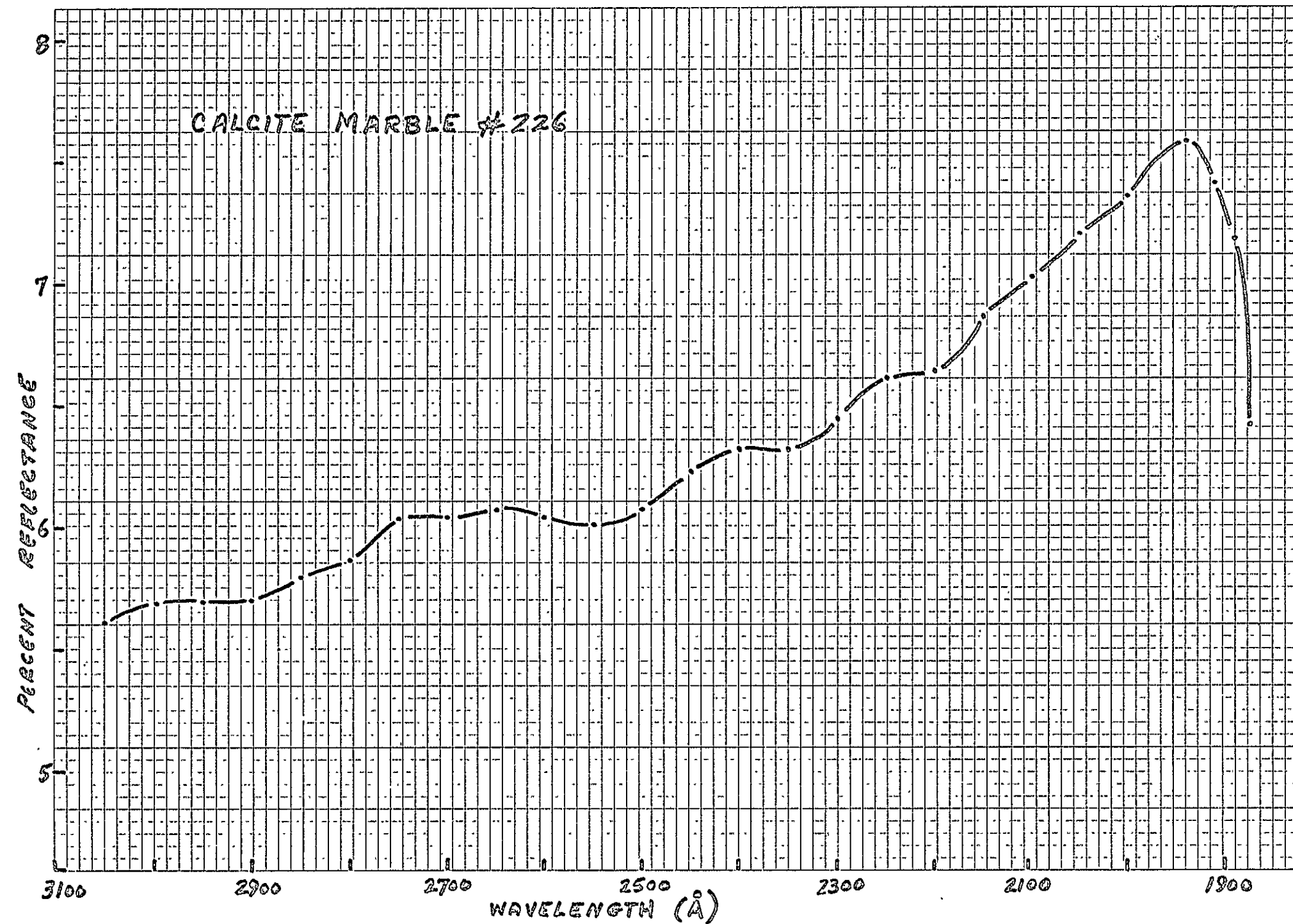
Figure 1

BASALT #101

12-17-65



CALCITE MARBLE #226



SERPENTINE # 236

12-23-65

PERCENT REFLECTANCE

3100

2900

2700

2500

2300

2100

1900

WAVELENGTH (Å)

EUGENE DITZGEN CO.
MADE IN U. S. A.

NO. 341-10 DITZGEN GRAPH PAPER
10 X 10 PER INCH

PLAGIOCLASE FELDSPAR-BYTOWNITE # 257

12-20-65

PERCENT REFLECTANCE

WAVELENGTH (Å)

3100

2900

2700

2500

2300

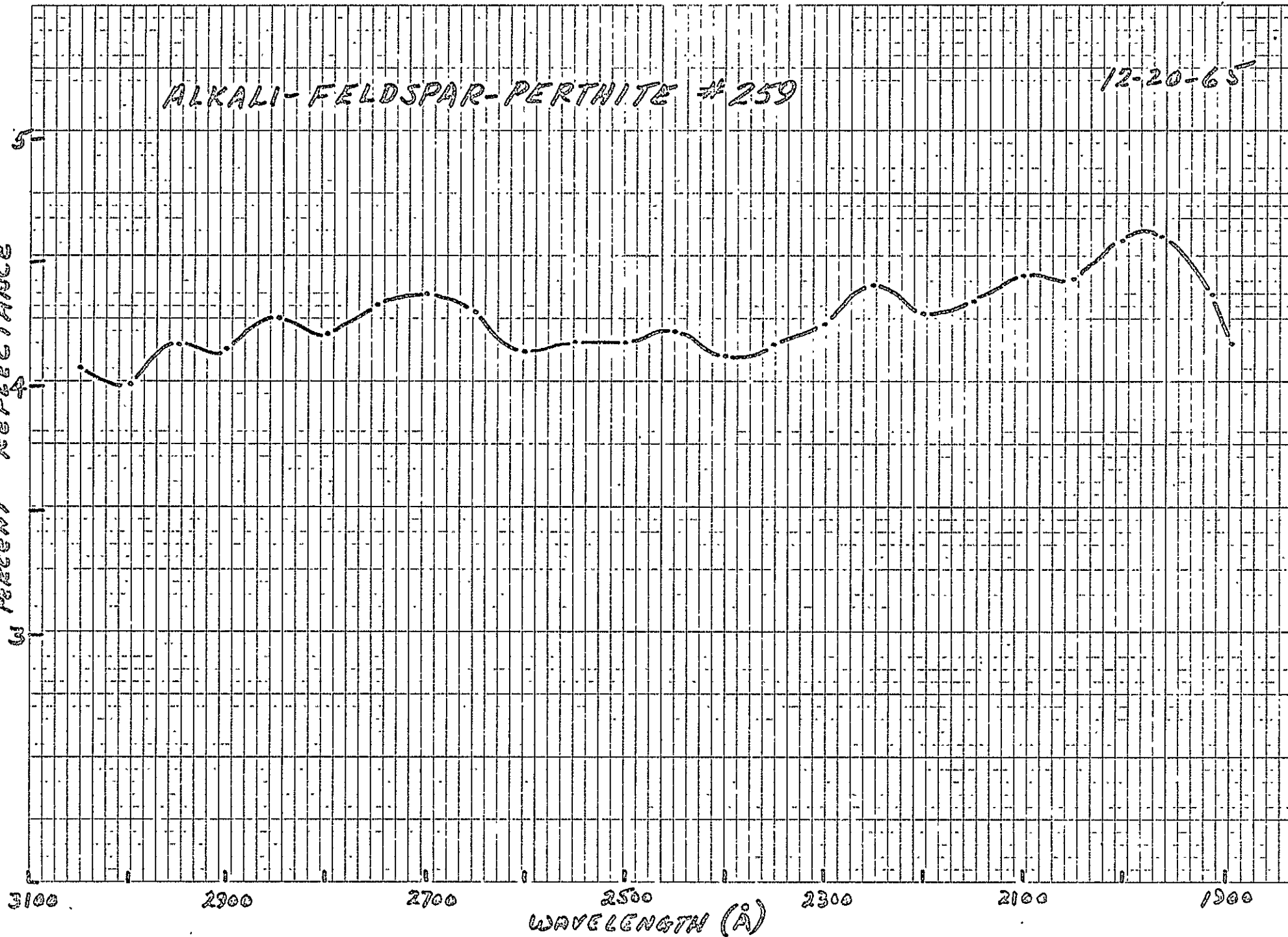
2100

1900

ALKALI-FELDSPAR-PERTHITE #259

12-20-65

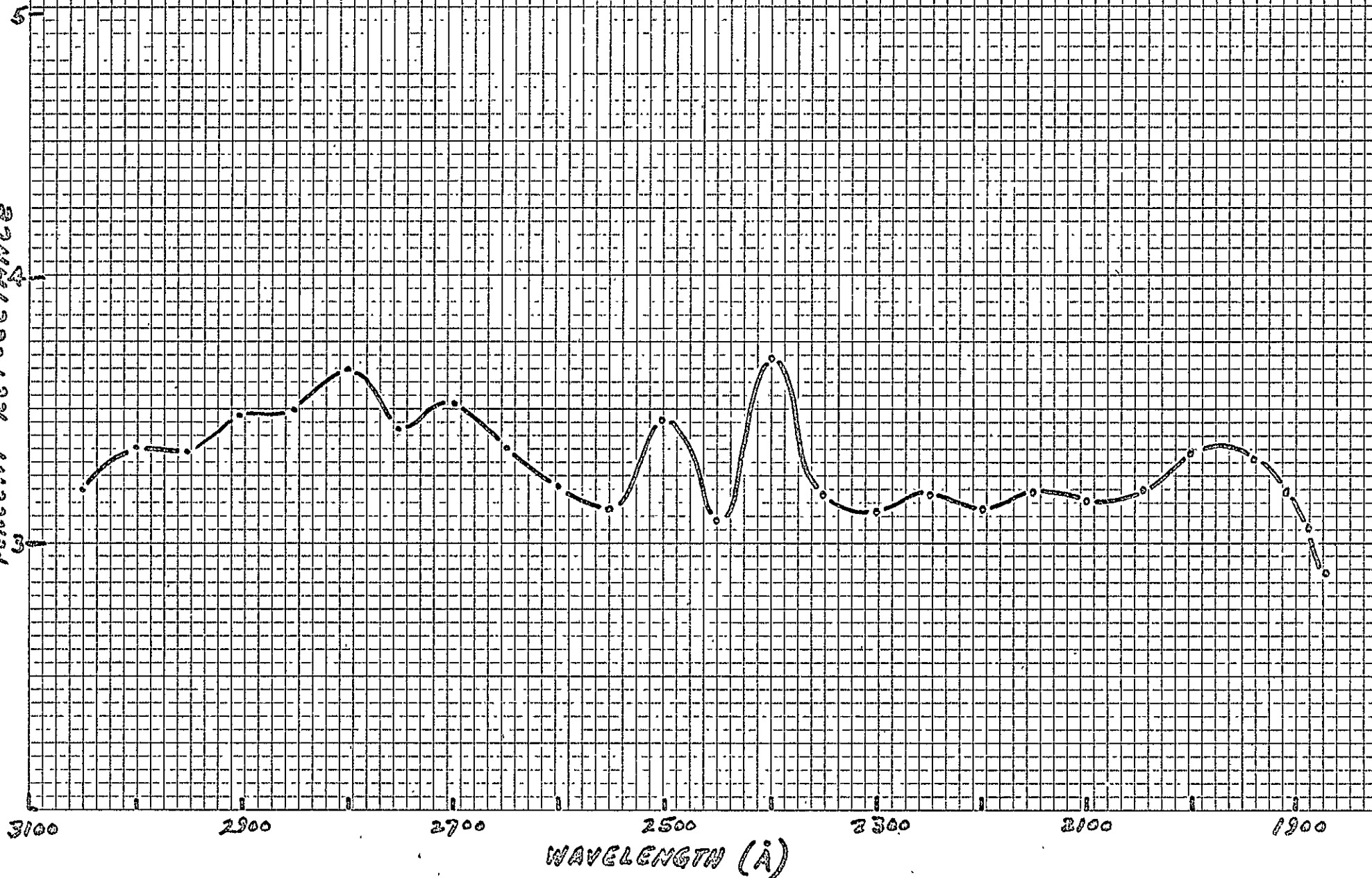
PERCENT REFLECTANCE



ALKALI-FELDSPAR ANORTHOCLASE #265

12-16-65

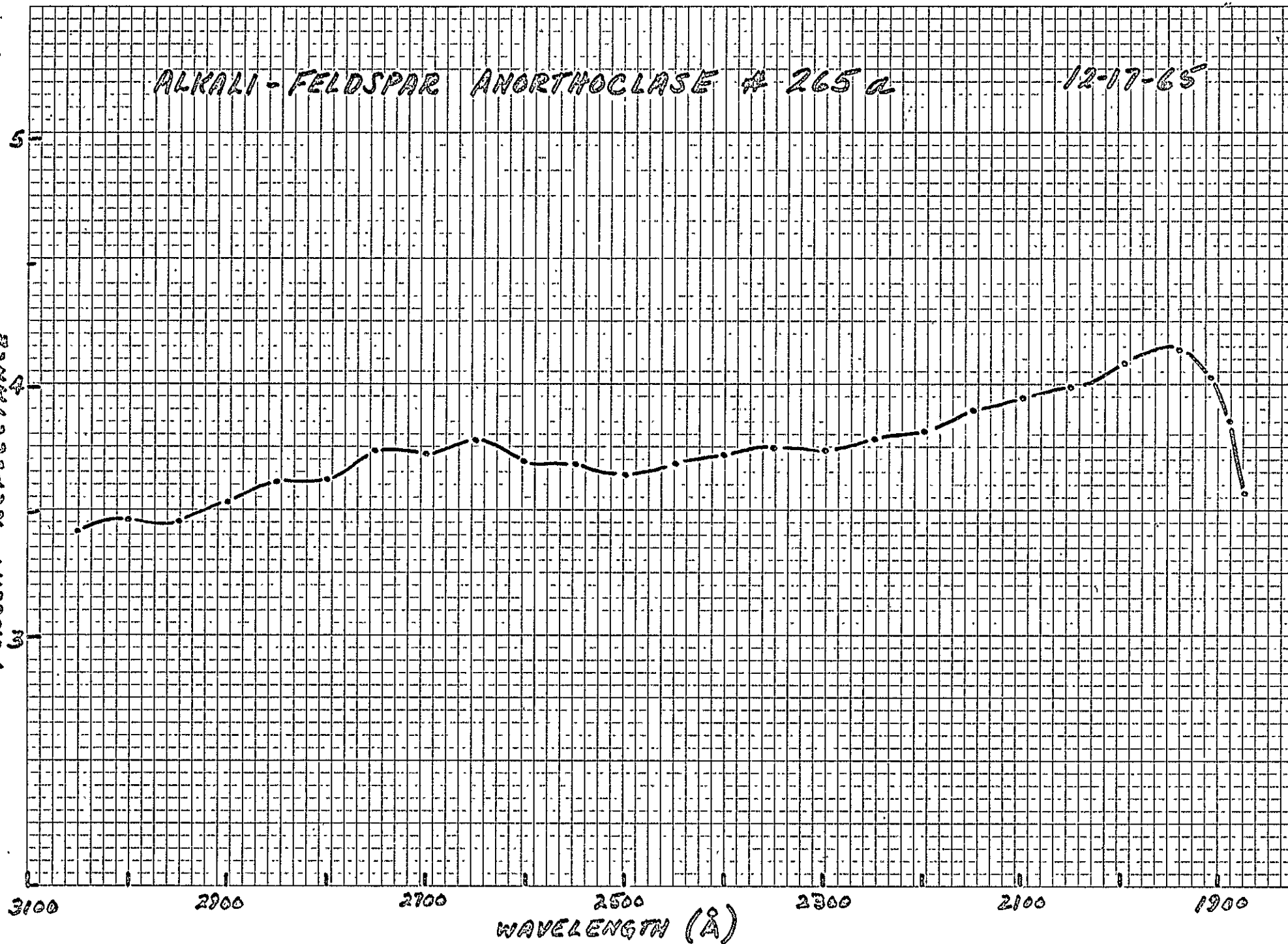
PERCENT REFLECTANCE



ALKALI-FELDSPAR ANORTHOCLASE # 265 a

12-17-65

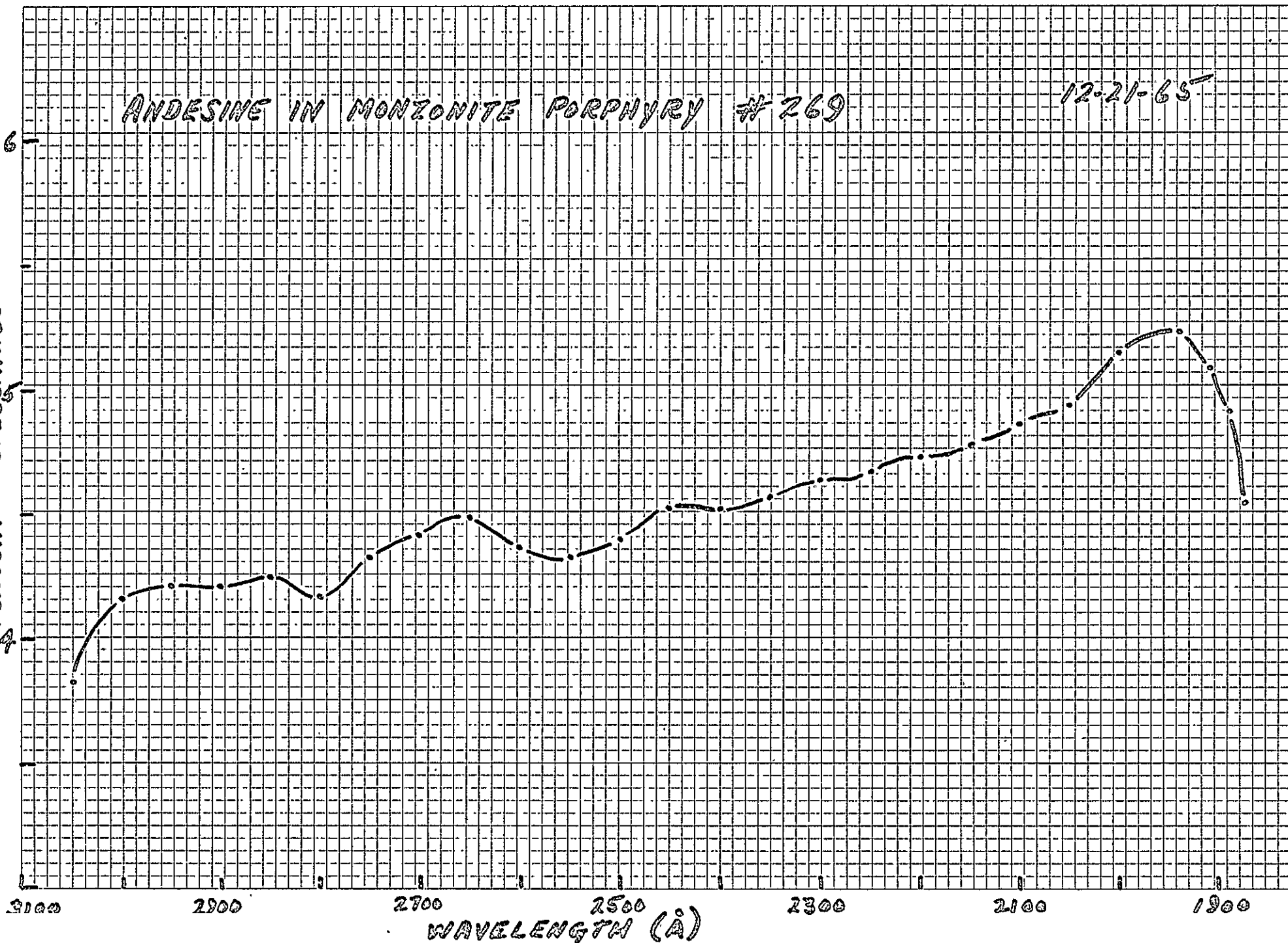
PERCENT REFLECTANCE



ANDESINE IN MONZONITE PORPHYRY #269

12-21-65

PERCENT REFLECTANCE



DIABASE PORPHYRY # 270

12-22-65

PERCENT REFLECTANCE

3100

2900

2700

2500

2300

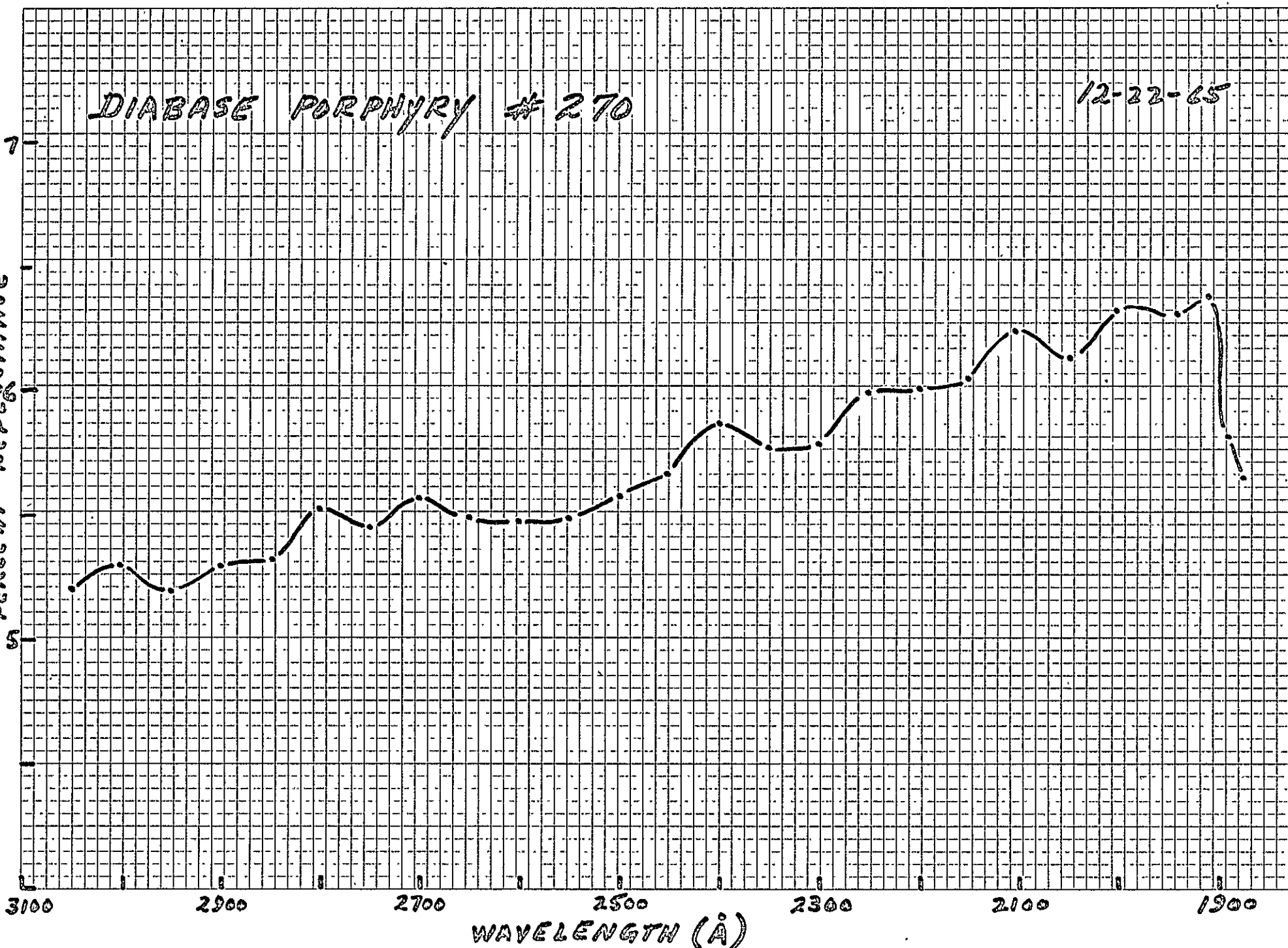
2100

1900

WAVELENGTH (Å)

EUGENE DITZGEN CO.
MADE IN U. S. A.

NO. 341-10 DITZGEN GRAPH PAPER
10 X 10 PER INCH



PYROXENE-AUGITE #277

12-16-65

PERCENT REFLECTANCE

3100

2900

2700

2500

2300

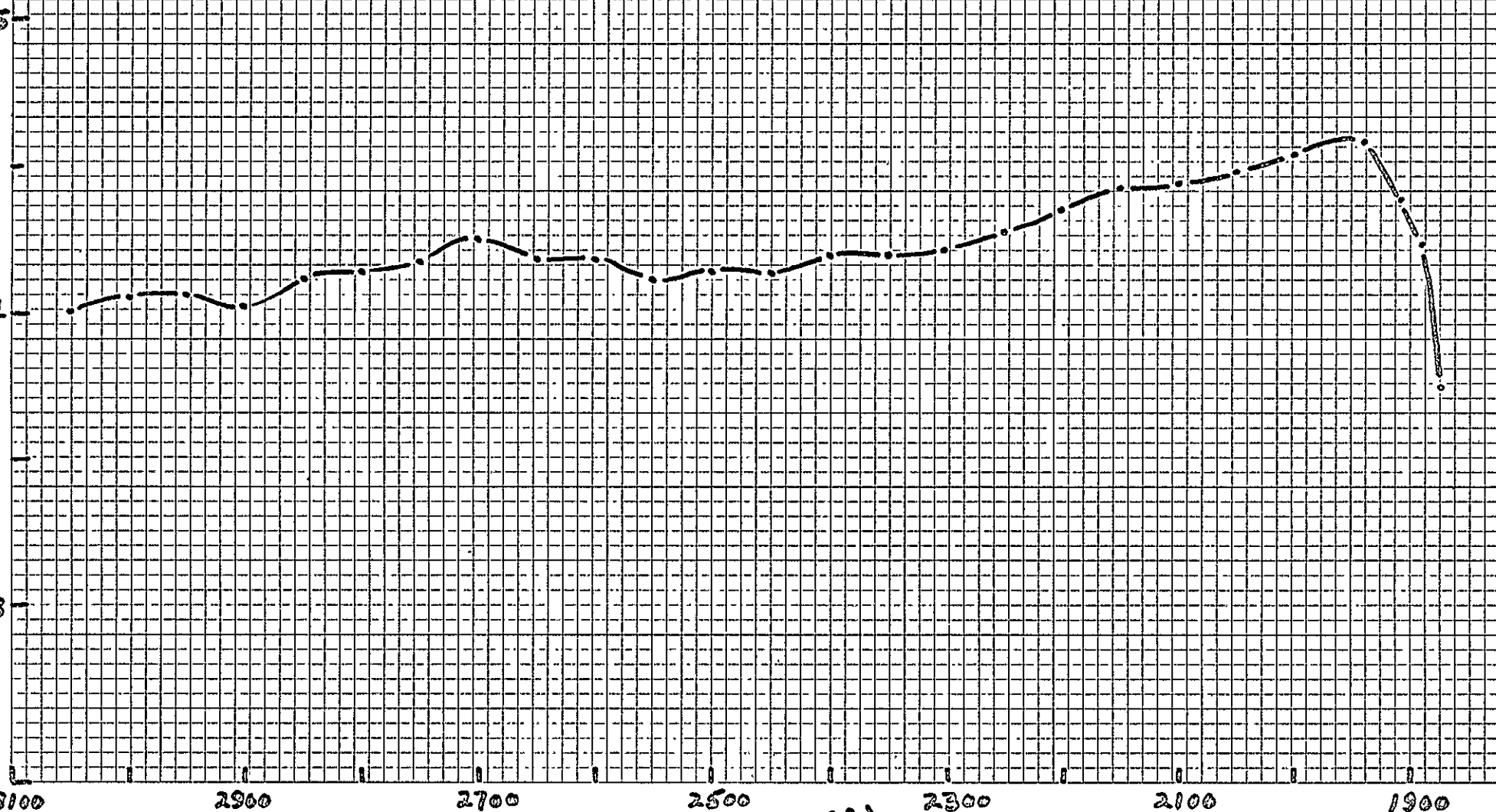
2100

1900

WAVELENGTH (Å)

EUGENE DIETZEN CO.
MADE IN U. S. A.

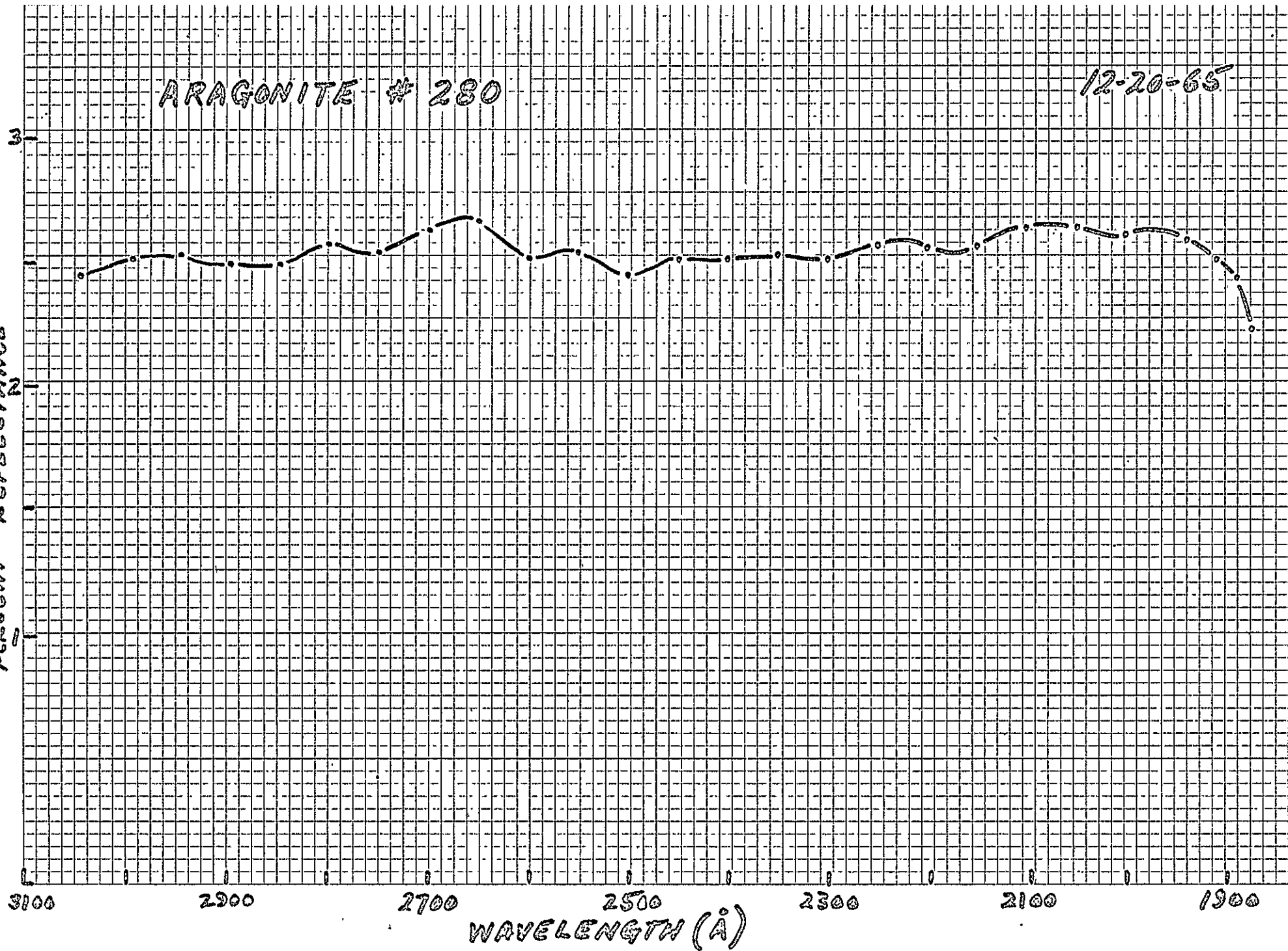
NO. 341-10 DIETZEN GRAPH PAPER
10 X 10 PER INCH



ARAGONITE # 280

12-20-65

PERCENT REFLECTANCE



NEPHELINE # 285

12-20-65

PERCENT REFLECTANCE

3100

2900

2700

2500

2300

2100

1900

WAVELENGTH (Å)

MUSCOVITE # 291

12-21-65

PERCENT REFLECTANCE

3100

2900

2700

2500

2300

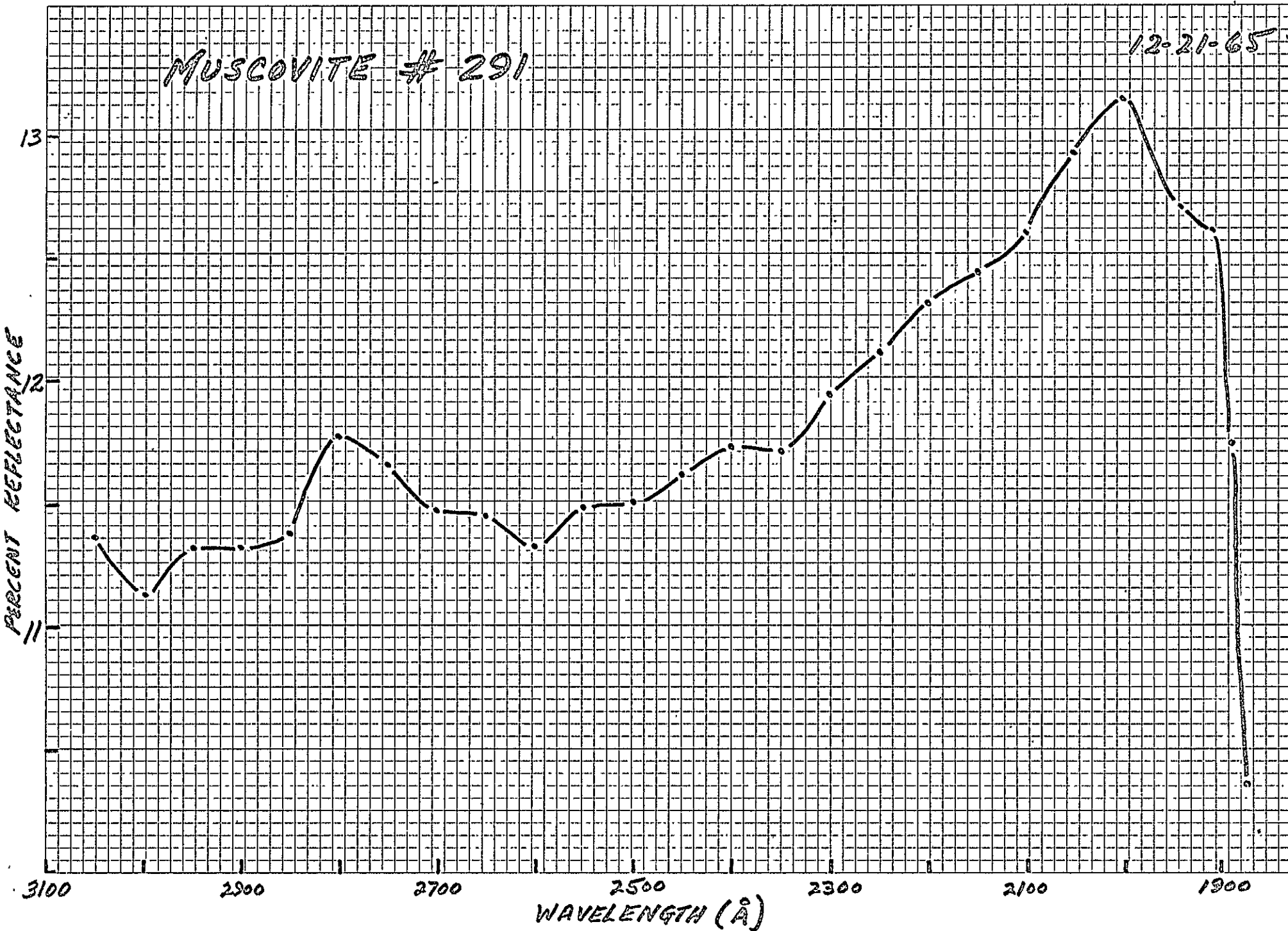
2100

1900

WAVELENGTH (Å)

EUGENE DIETZEN CO.
MADE IN U. S. A.

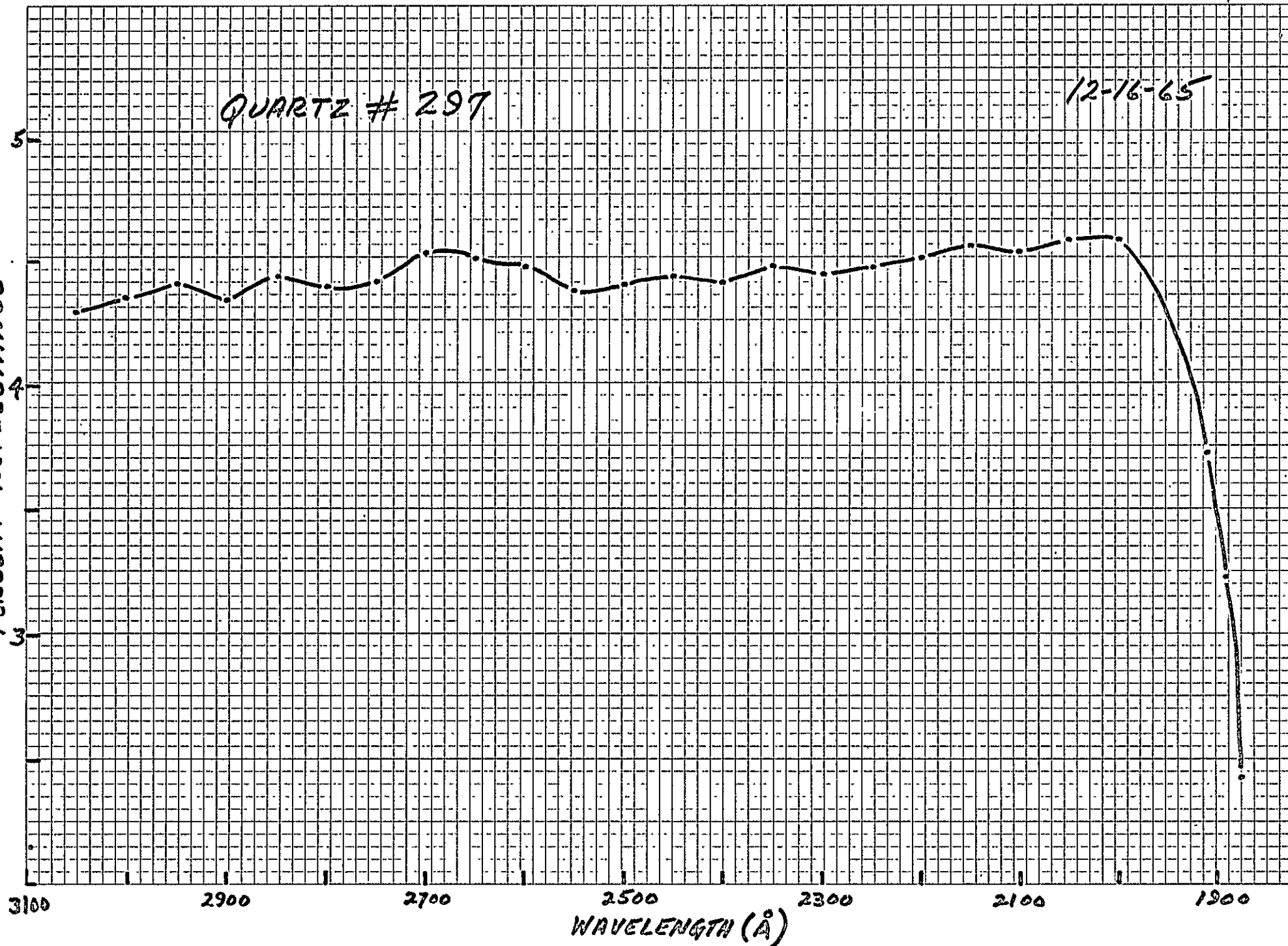
NO. 341-10 DIETZEN GRAPH PAPER
10 X 10 PER INCH



QUARTZ # 297

12-16-65

PERCENT REFLECTANCE



BERYL #298

12-21-65

PERCENT REFLECTANCE

3100

2900

2700

2500

2300

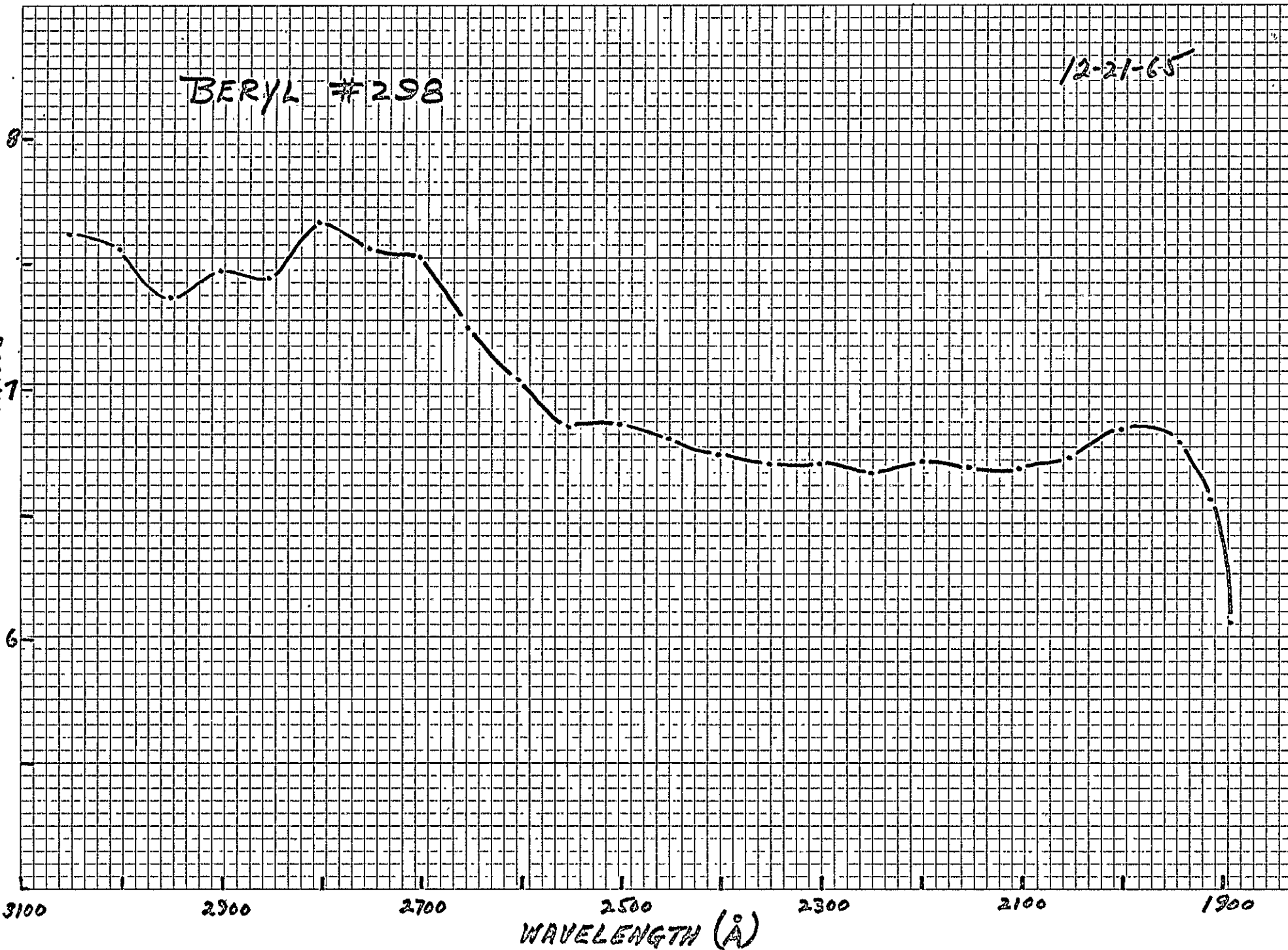
2100

1900

WAVELENGTH (Å)

EUGENE DIETZGEN CO.
MADE IN U. S. A.

NO. 341-10 DIETZGEN GRAPH PAPER
10 X 10 PER INCH



RED GRANITE # 300

12-27-65

PERCENT REFLECTANCE

3100

2900

2700

2500

2300

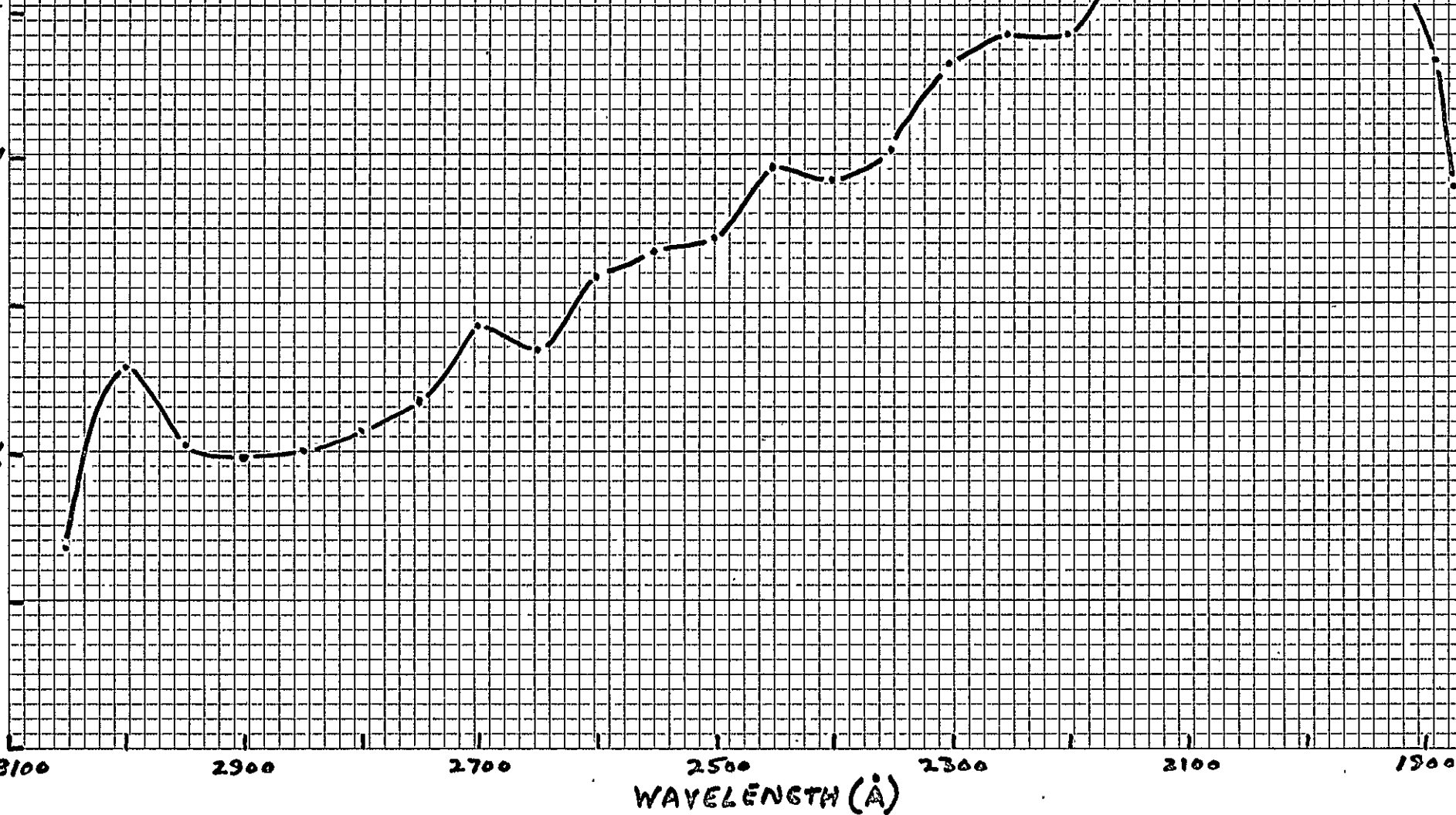
2100

1900

WAVELENGTH (Å)

EUGENE DIETZEN CO.
MADE IN U. S. A.

NO. 341-10 DIETZEN GRAPH PAPER
10 X 10 PER INCH



DARK PEARL GRANITE #301

12-23-65

PERCENT REFLECTANCE

3100

2900

2700

2500

2300

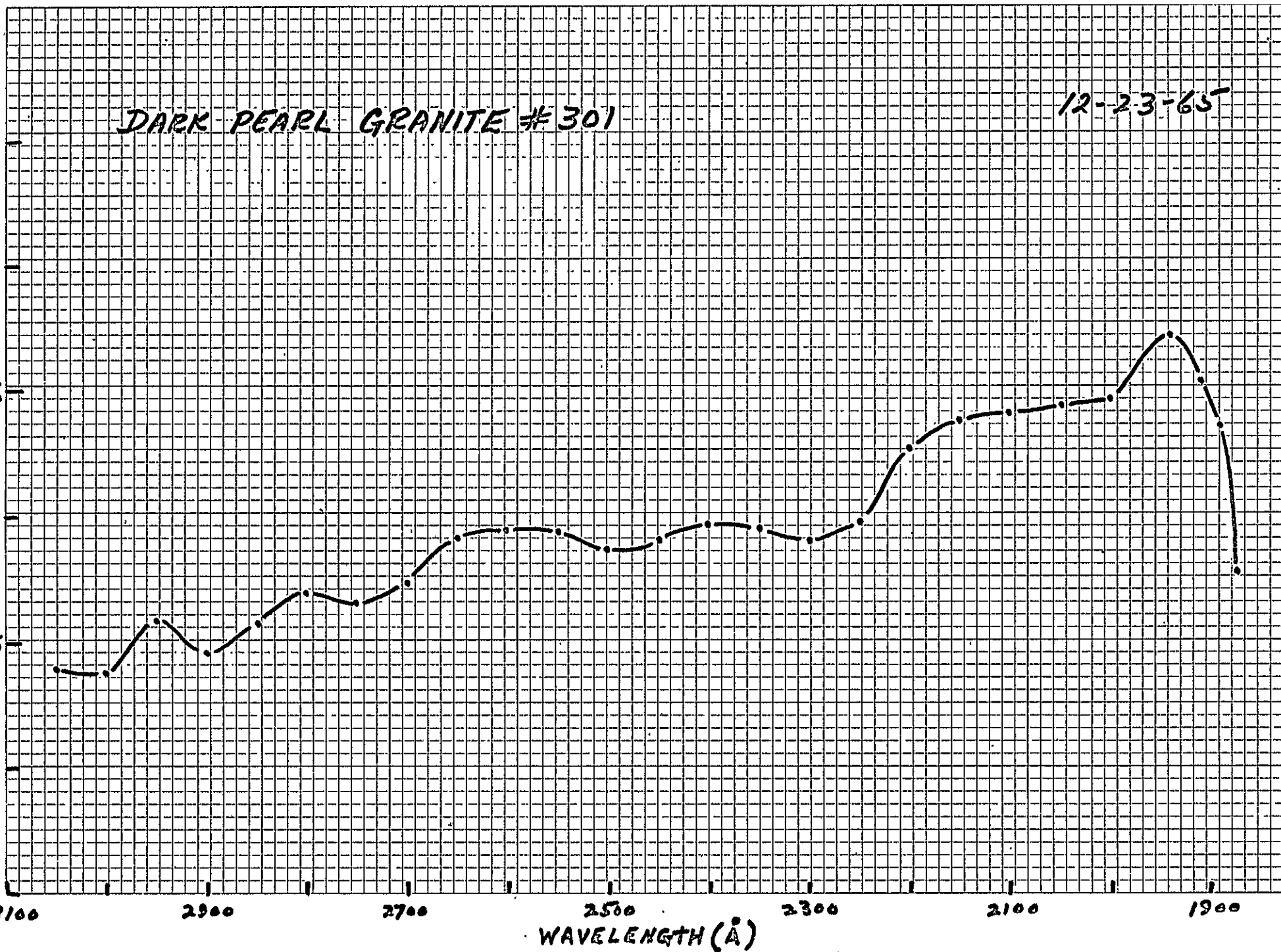
2100

1900

WAVELENGTH (Å)

EUGENE DIETZEN CO.
MADE IN U. S. A.

NO. 341-10 DIETZEN GRAPH PAPER
10 X 10 PER INCH



GRAY GRANITE # 302

12-27-65

PERCENT REFLECTANCE

6

5

4

3100

2900

2700

2500

2300

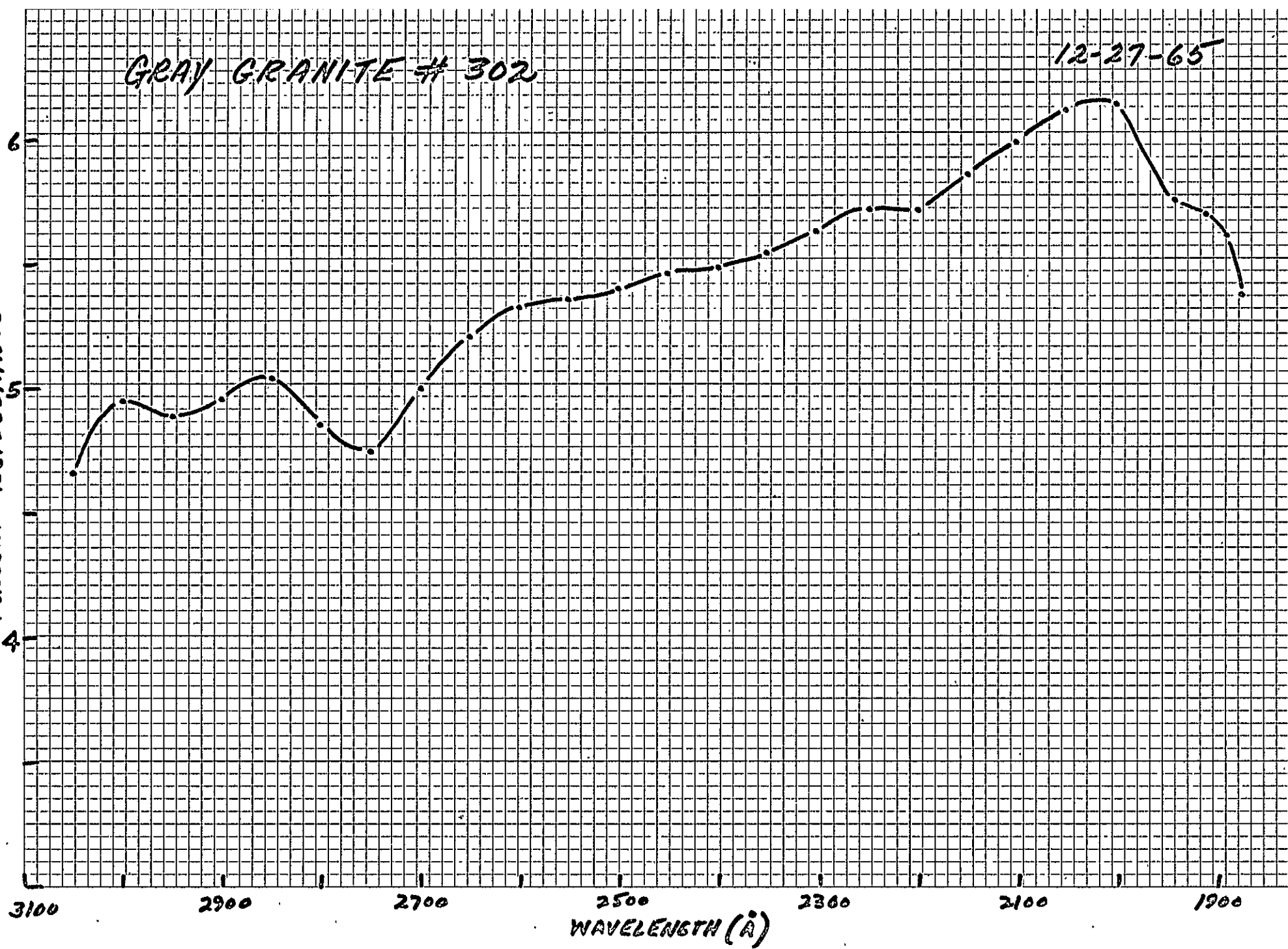
2100

1900

WAVELENGTH (Å)

EUGENE DIETZGEN CO.
MADE IN U. S. A.

NO. 341-10 DIETZGEN GRAPH PAPER
10 X 10 PER INCH



BLUE GRANITE # 303

12-27-65

PERCENT REFLECTANCE

3100

2900

2700

2500

2300

2100

1900

WAVELENGTH (Å)

EUGENE DIETZGEN CO.
MADE IN U. S. A.

NO. 341-10 DIETZGEN GRAPH PAPER
10 X 10 PER INCH

9

8

7

6

5

4

3

2

1

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

BLUE GRANITE # 304

PERCENT REFLECTANCE

3100

2900

2700

2500

2300

2100

1900

WAVELENGTH (Å)

EUGENE DICTZGEN CO.
MADE IN U. S. A.

NO. 341-10 DICTZGEN GRAPH PAPER
10 X 10 PER INCH

PINK GRANITE #305

12-28-65

PERCENT REFLECTANCE

3100

2900

2700

2500

2300

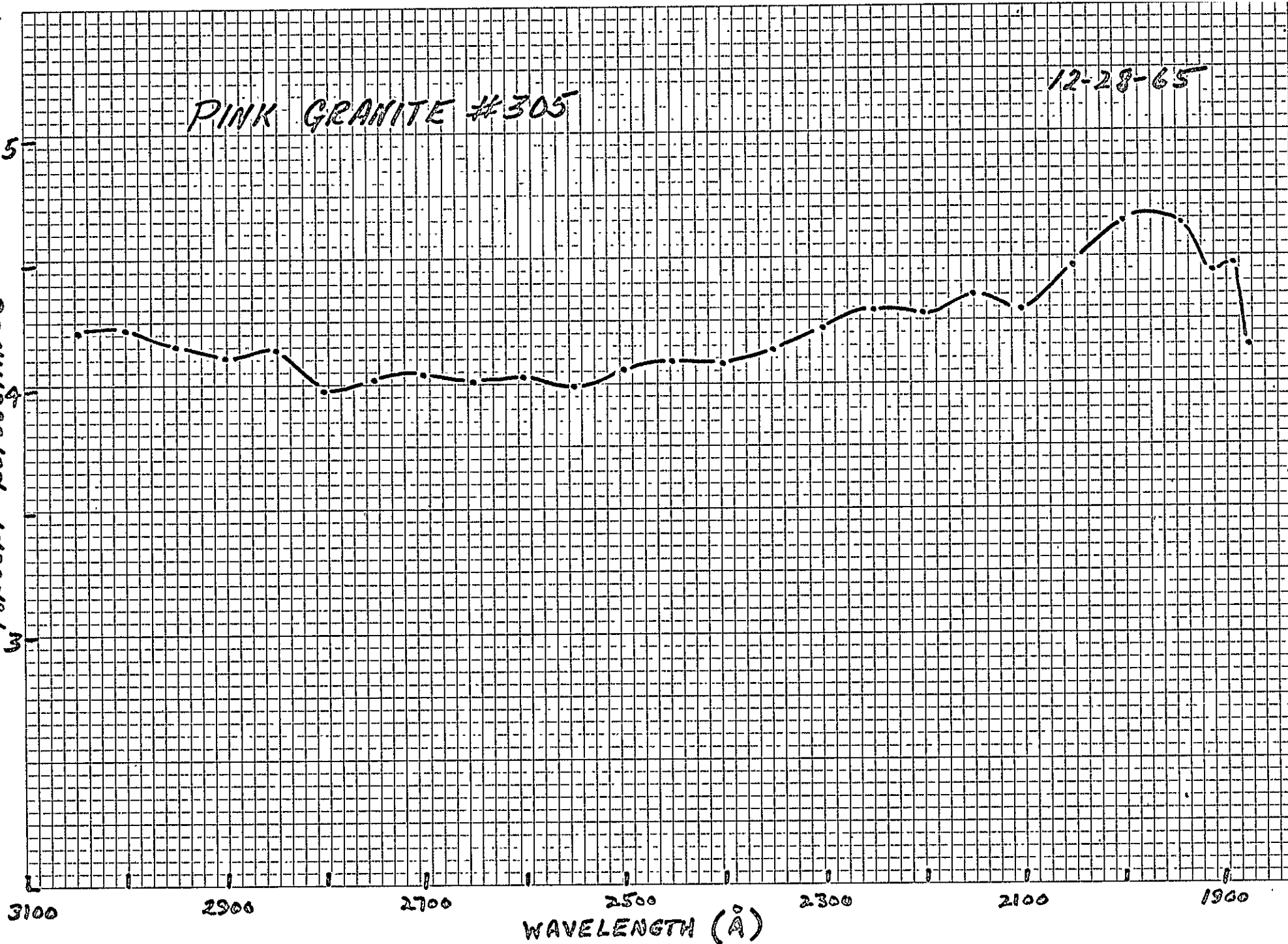
2100

1900

WAVELENGTH (Å)

EUGENE DIETZEN CO.
MADE IN U. S. A.

NO. 341-10 DIETZEN GRAPH PAPER
10 X 10 PER INCH



RED GRANITE #306

PERCENT REFLECTANCE

3100

2900

2700

2500

2300

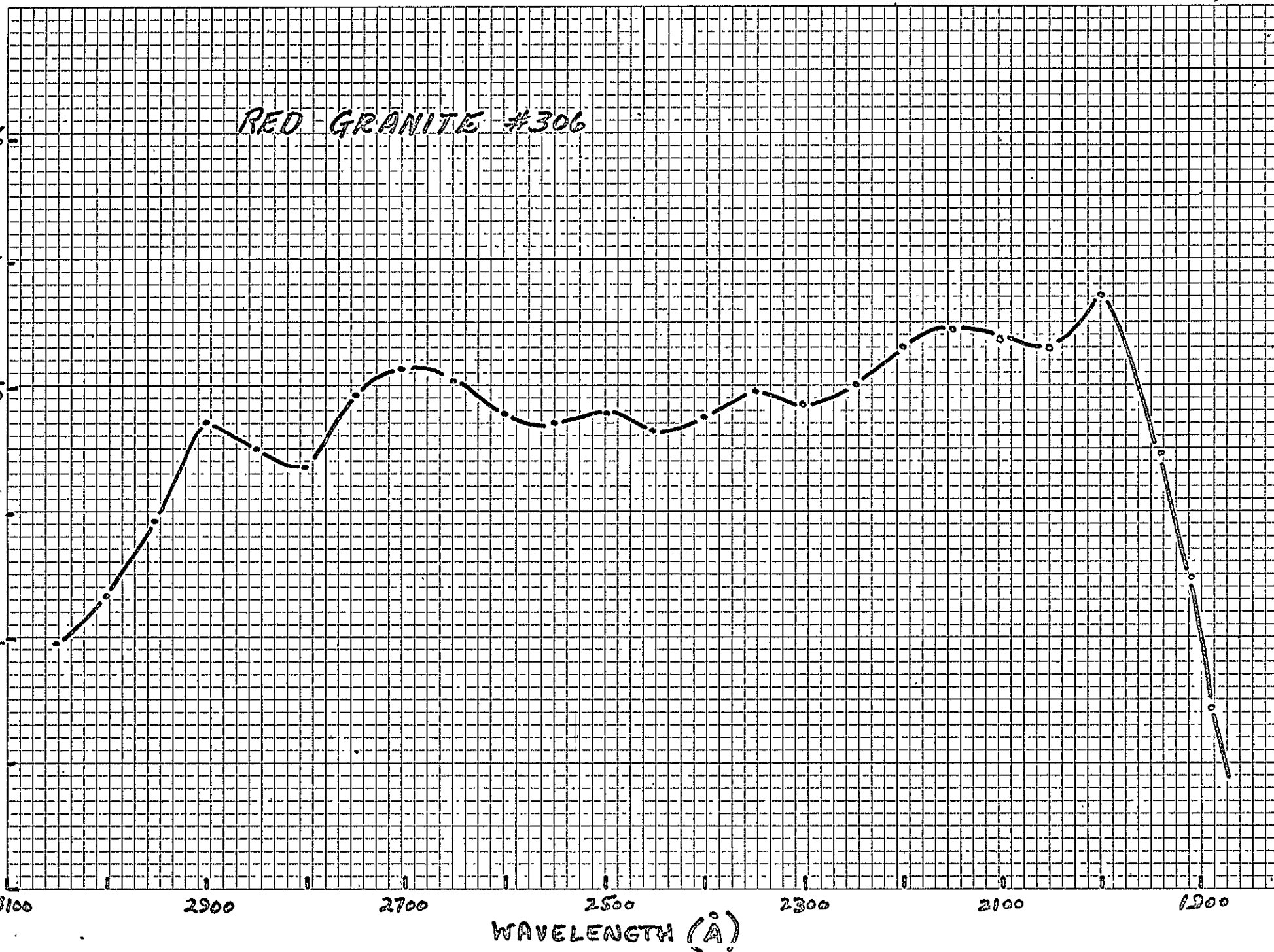
2100

1900

WAVELENGTH (Å)

EUGENE DIETZEN CO.
MADE IN U. S. A.

NO. 341-10 DIETZEN GRAPH PAPER
10 X 10 PER INCH



GRANITE # 307

12-27-65

PERCENT REFLECTANCE

3100

2900

2700

2500

2300

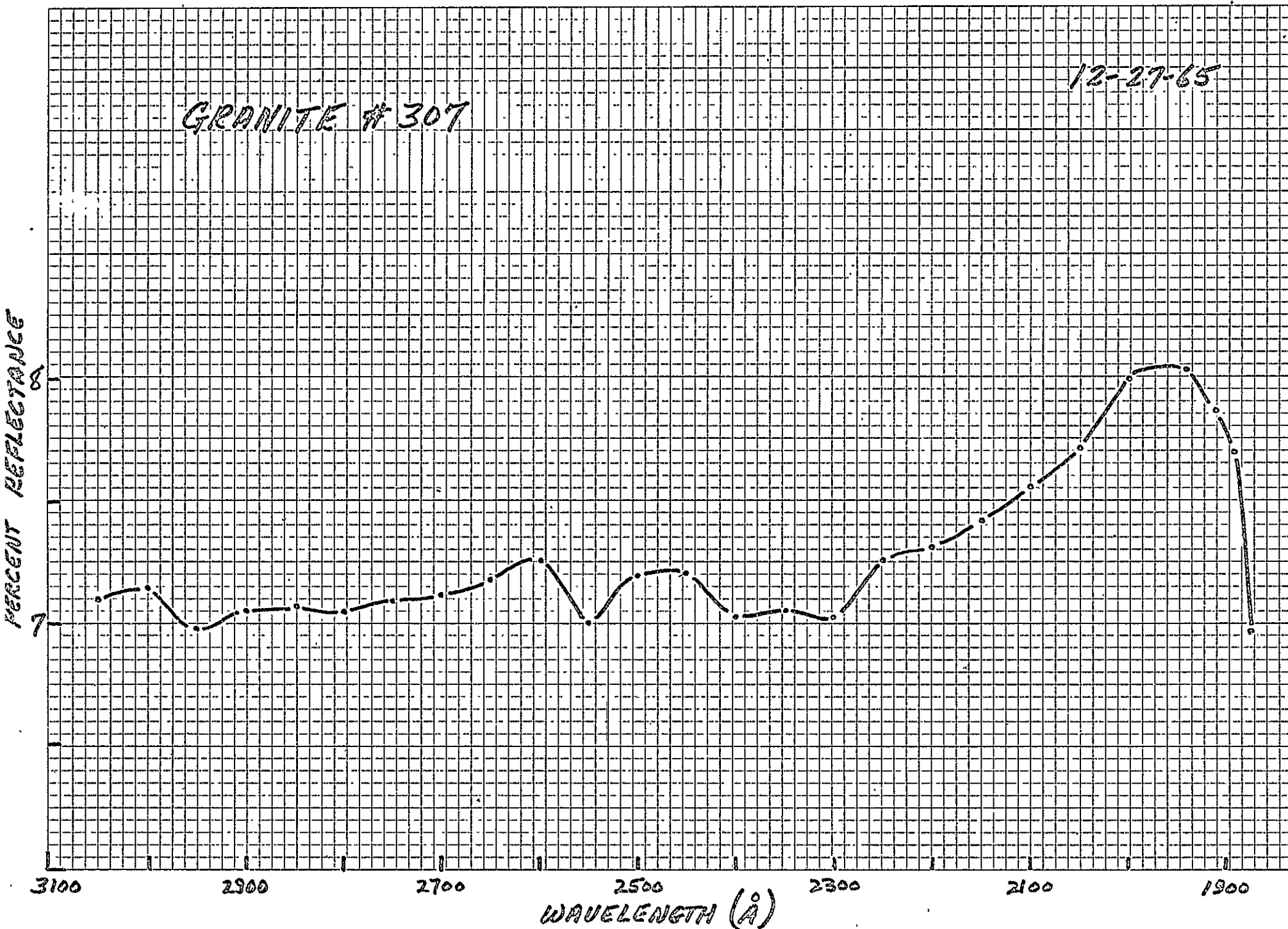
2100

1900

WAVELENGTH (\AA)

EUGENE DIETZEN CO.
MADE IN U. S. A.

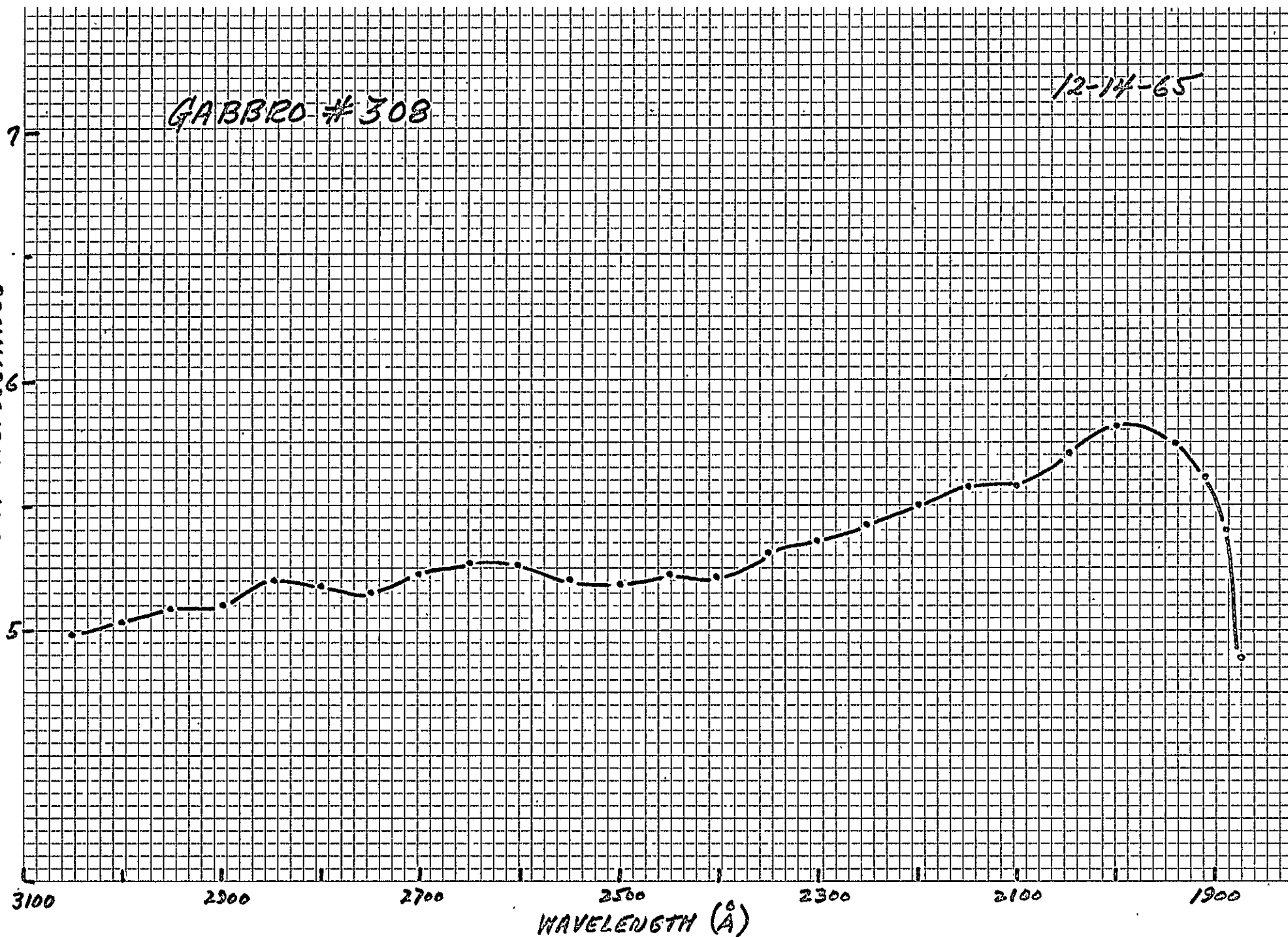
NO. 341-10 DIETZEN GRAPH PAPER
10 X 10 PER INCH



GABRO #308

12-14-65

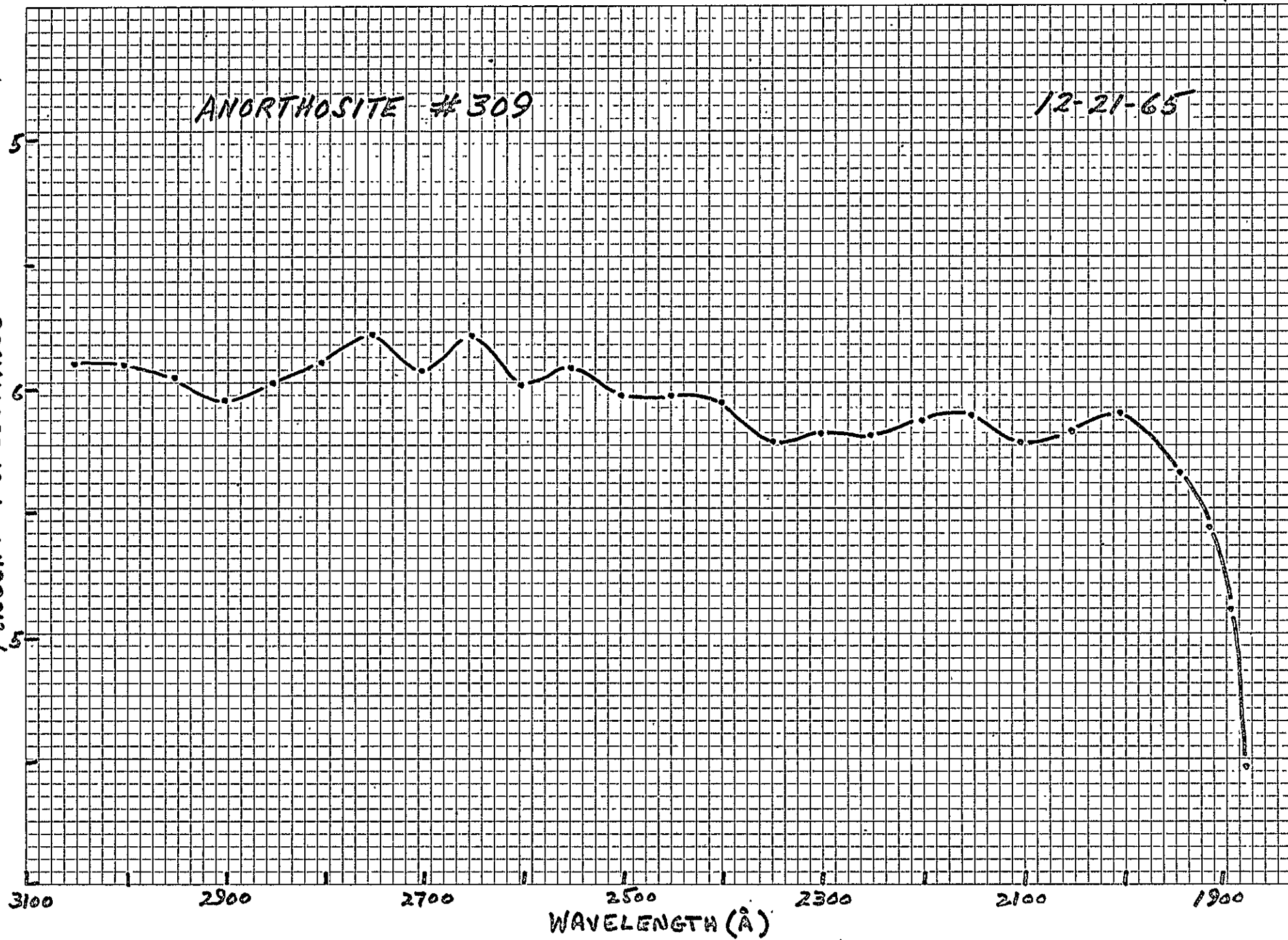
PERCENT REFLECTANCE



ANORTHOSITE #309

12-21-65

PERCENT REFLECTANCE



GRANODIORITE # 315

12-17-65

PERCENT REFLECTANCE

3100

2900

2700

2500

2300

2100

1900

WAVELENGTH (Å)

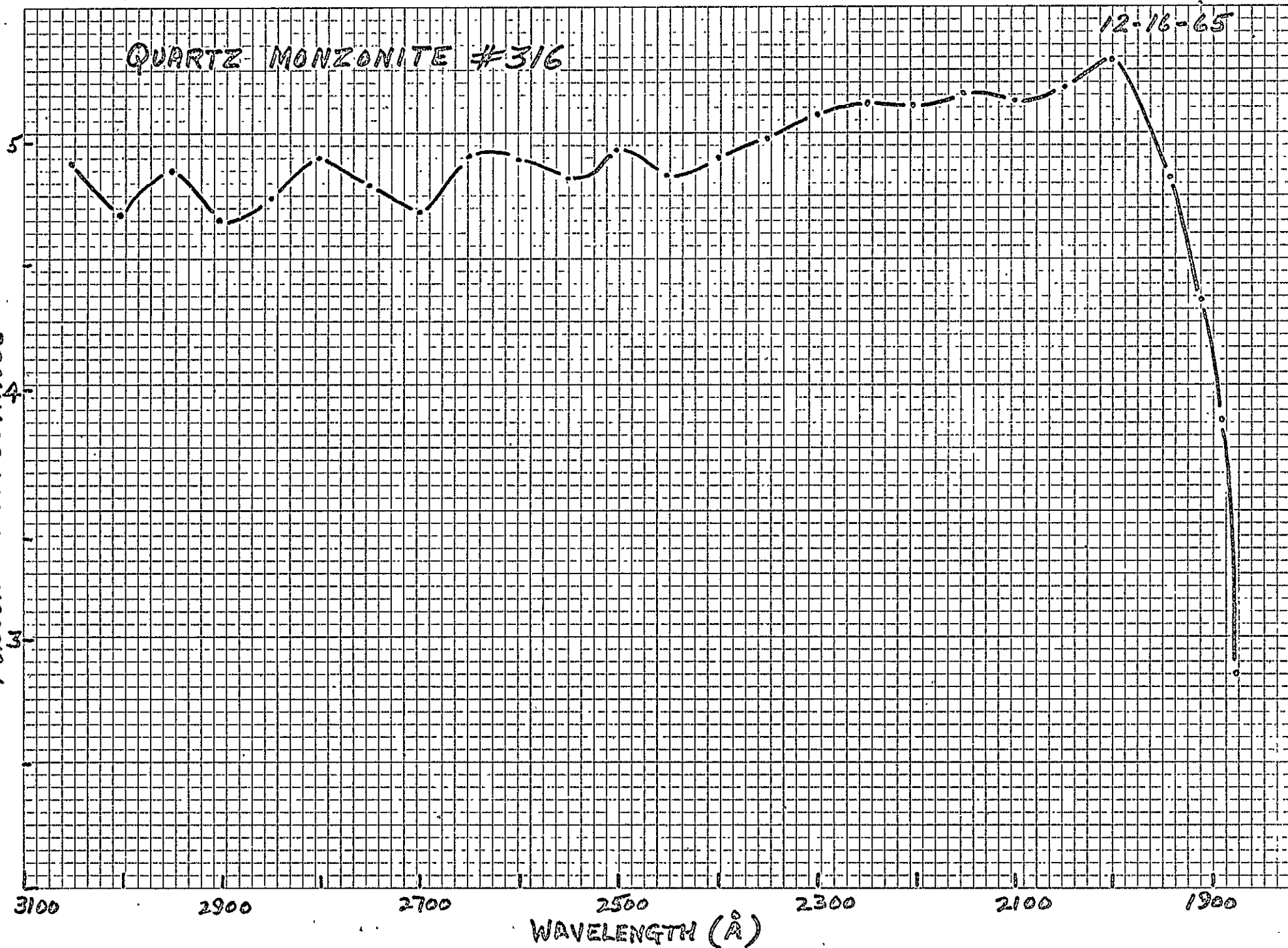
QUARTZ MONZONITE #316

12-16-65

PERCENT REFLECTANCE

WAVELENGTH (Å)

3100 2900 2700 2500 2300 2100 1900



BIOTITE QUARTZ MONZONITE #320

12-23-65

PERCENT REFLECTANCE

3100

2900

2700

2500

2300

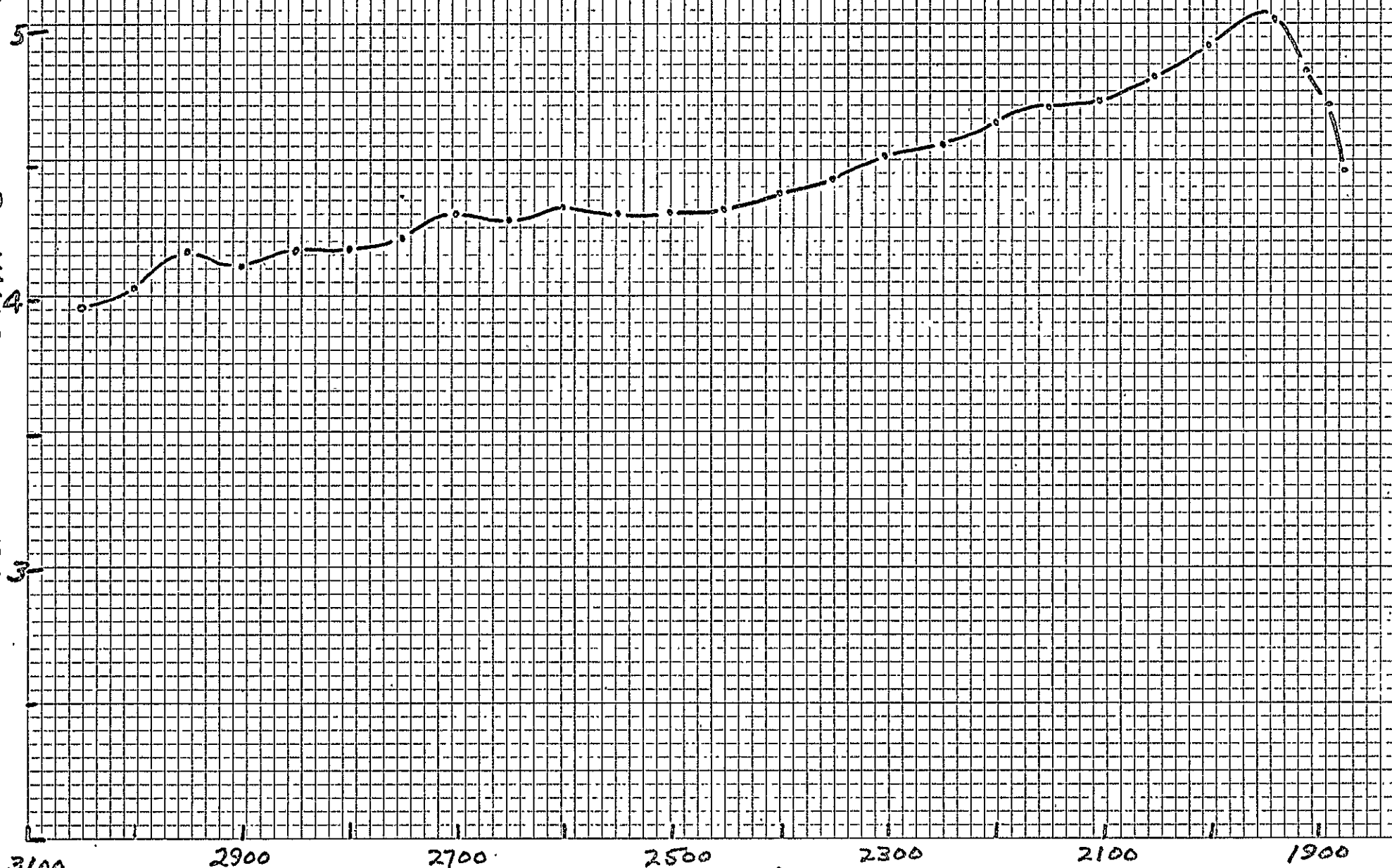
2100

1900

WAVELENGTH (Å)

EUGENE DIETZEN CO.
MADE IN U. S. A.

NO. 341-10 DIETZEN GRAPH PAPER
10 X 10 PER INCH



HORNBLENDE-BIOTITE GRANODIORITE #323

12-28-65

PERCENT REFLECTANCE

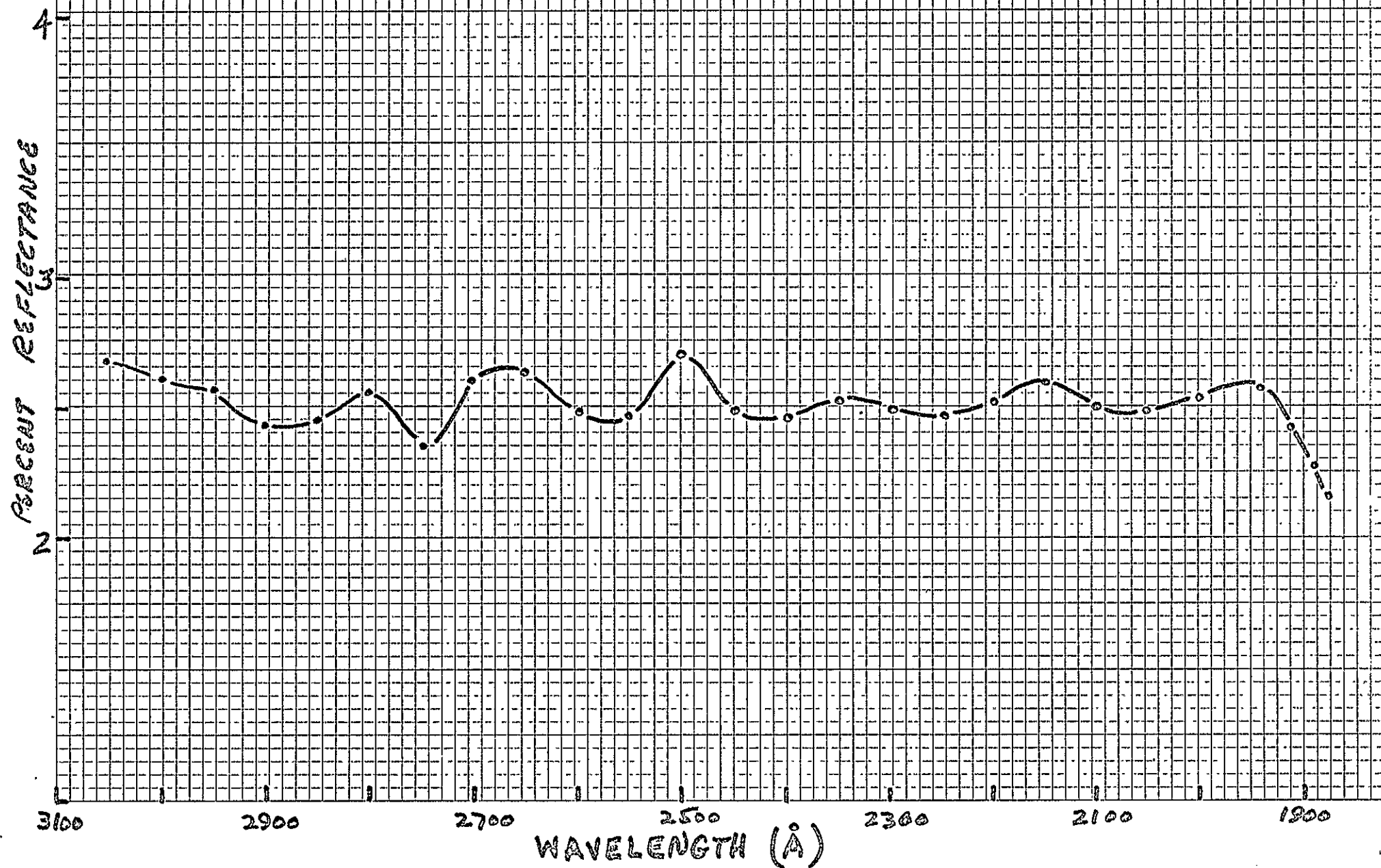
3100 2900 2700 2500 2300 2100 1900
WAVELENGTH (Å)

NO. 341-10 DIETZGEN GRAPH PAPER
EUGENE DIETZGEN CO.
MADE IN U. S. A.

5

4

PHYOLITE OBSIDIAN # 325



12-22-65

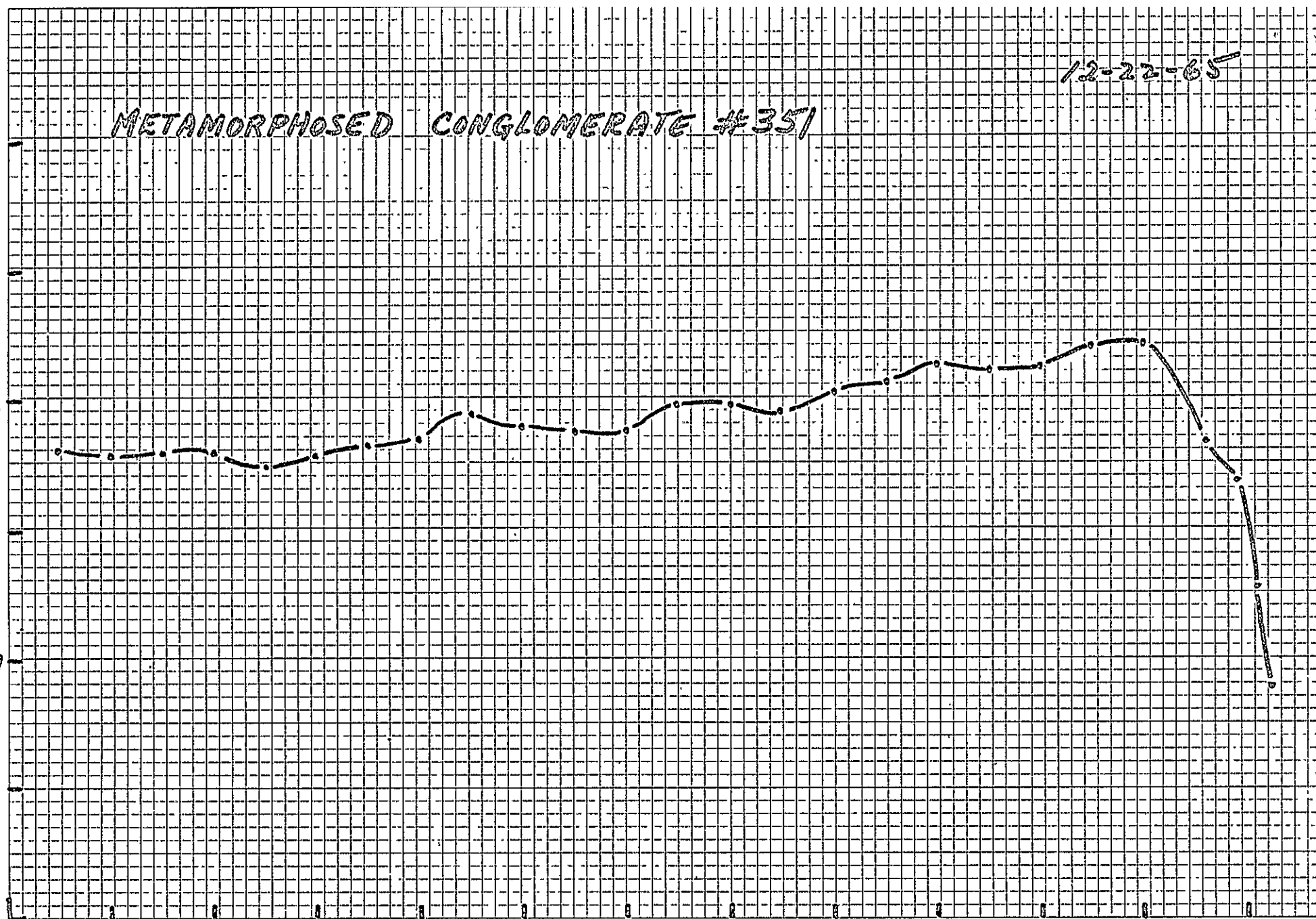
METAMORPHOSED CONGLOMERATE #351

PERCENT REFLECTANCE

3100 2900 2700 2500 2300 2100 1900

WAVELENGTH (Å)

NO. 341-10 DIETZEN GRAPH PAPER
EUGENE DIETZEN CO.
MADE IN U. S. A.
10 X 10 PER INCH



12-23-85

POPHYRITIC QUARTZ MONZONITE #352

PERCENT REFLECTANCE

WAVELENGTH (Å)

3100

2900

2700

2500

2300

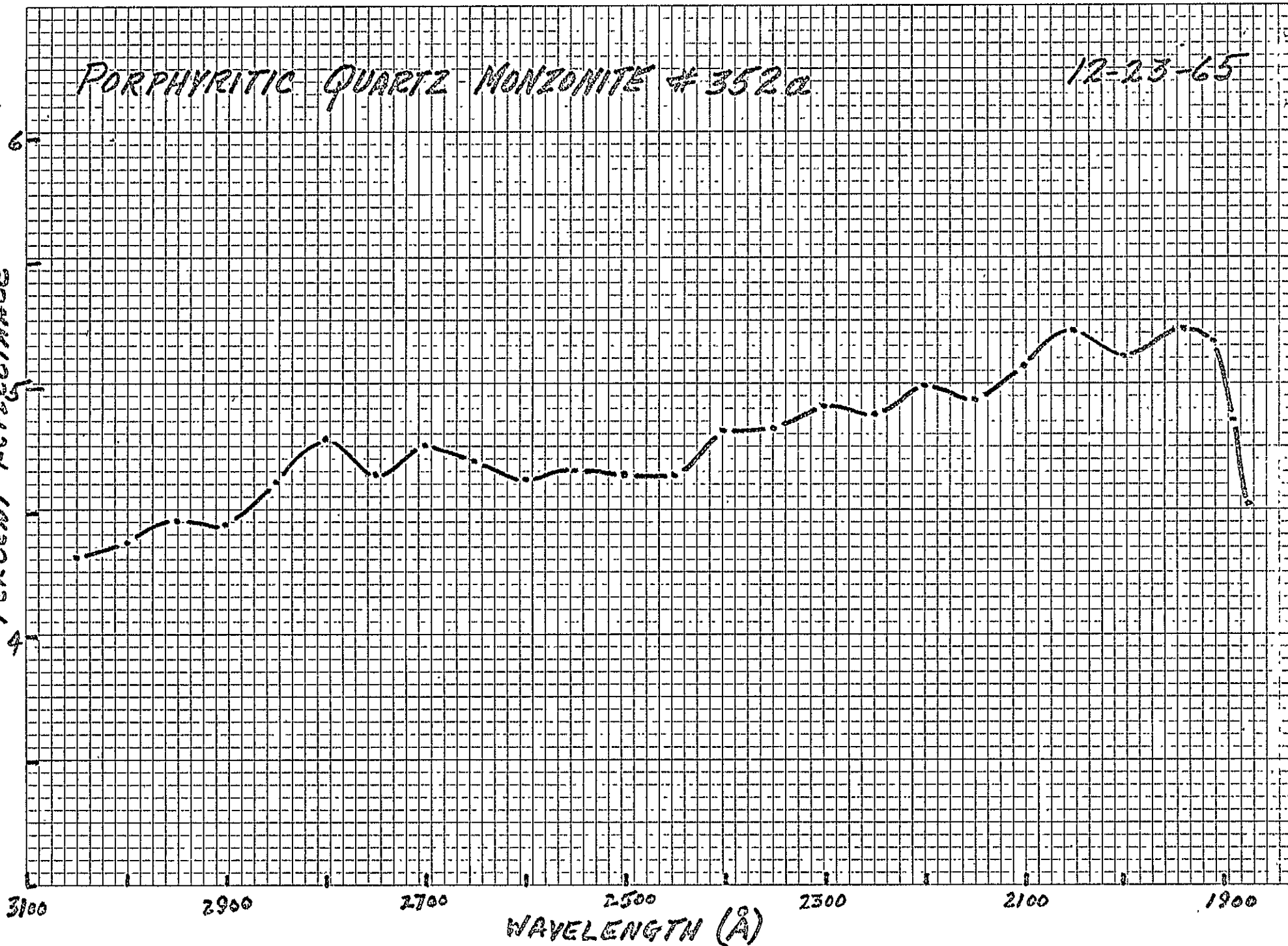
2100

1900

PORPHYRITIC QUARTZ MONZONITE #352a

12-23-65

PERCENT REFLECTANCE



GRANODIORITE #353

12-17-65

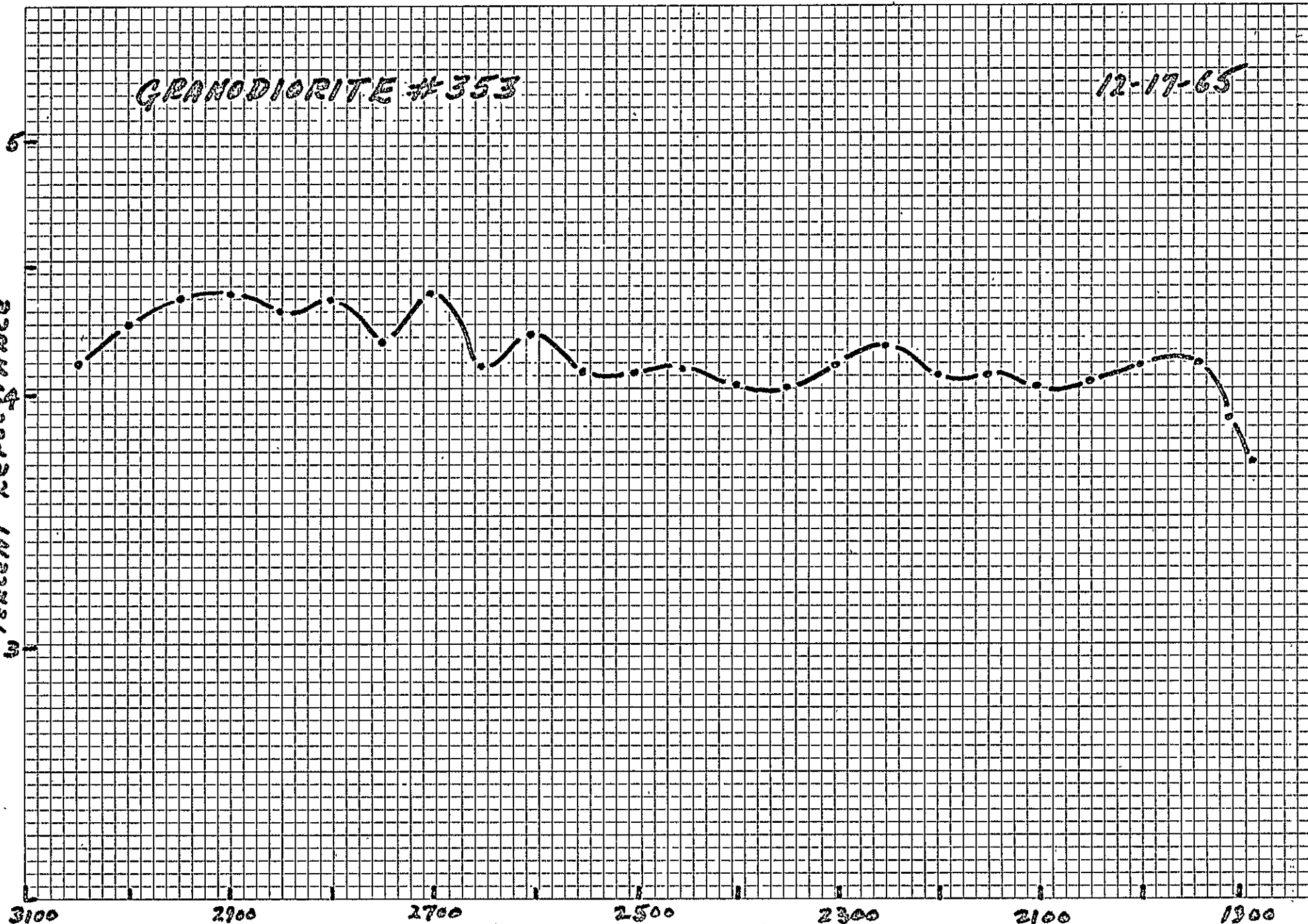
PERCENT REFLECTANCE

WAVELENGTH (Å)

3100 2900 2700 2500 2300 2100 1900

EUGENE DIETZGEN CO.
MADE IN U. S. A.

NO. 341-10 DIETZGEN GRAPH PAPER
10 X 10 PER INCH



PHYLLITE # 354

12-28-65

PERCENT REFLECTANCE

3100

2900

2700

2500

2300

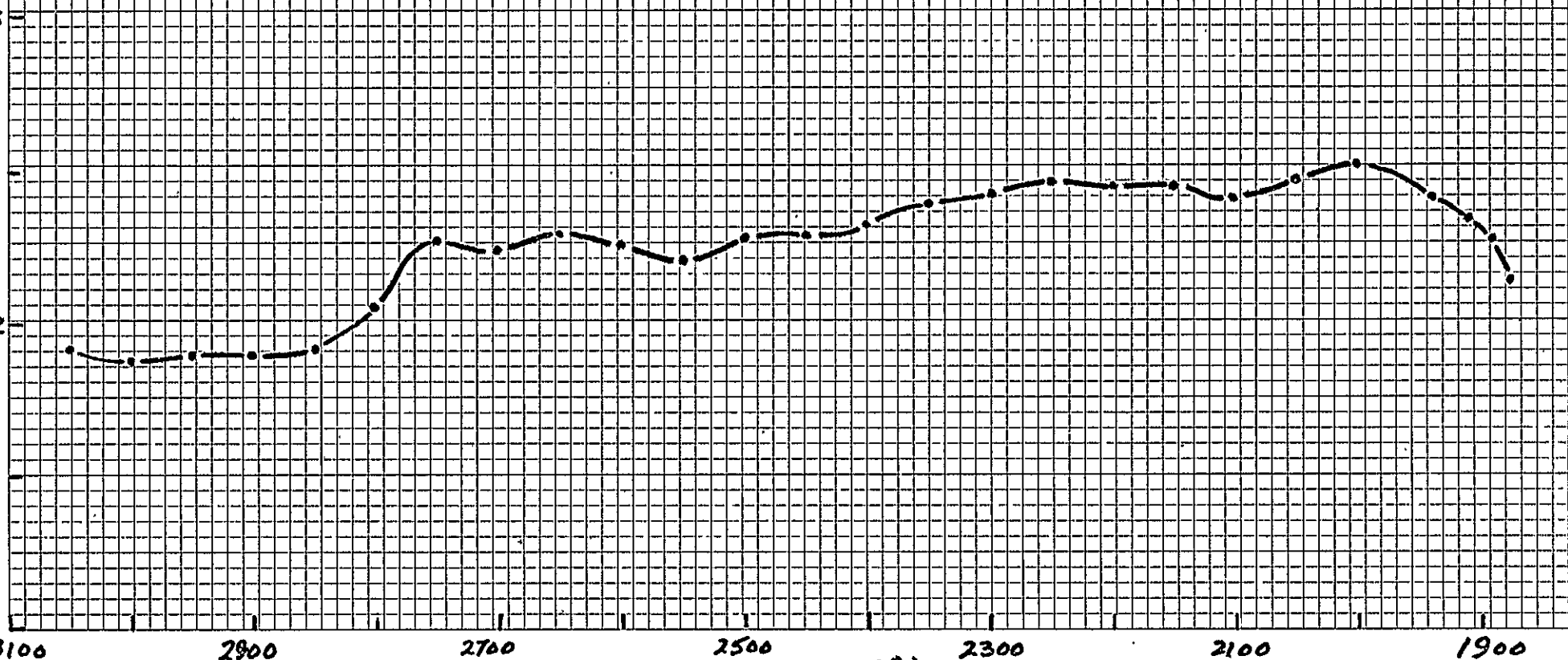
2100

1900

WAVELENGTH (Å)

EUGENE DICTZEN CO.
MADE IN U. S. A.

ND. 341-10 DIETZEN GRAPH PAPER
10 X 10 PER INCH



GRANITE # 355

12-17-65

PERCENT REFLECTANCE

4

5

6

3100

2900

2700

2500

2300

2100

1900

WAVELENGTH (\AA)

CALCITE CRYSTAL #365

12-21-65

PERCENT REFLECTANCE

8

7

6

3100

2900

2700

2500

2300

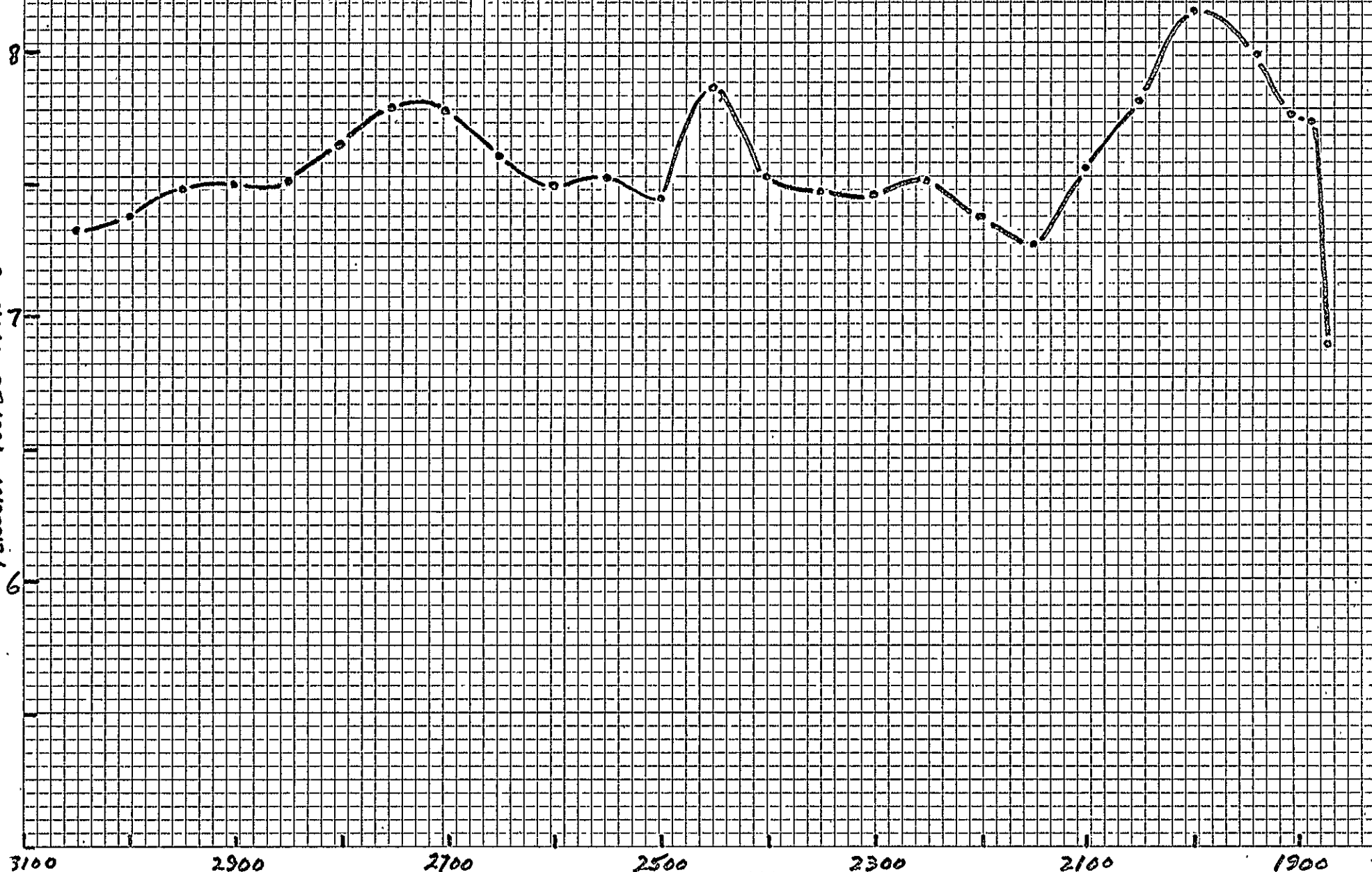
2100

1900

WAVELENGTH (\AA)

EUGENE DIETZEN CO.
MADE IN U. S. A.

NO. 341-10 DIETZEN GRAPH PAPER
10 X 10 PER INCH



FLUORITE # 366

12-22-65

PERCENT REFLECTANCE

3100

2900

2700

2500

2300

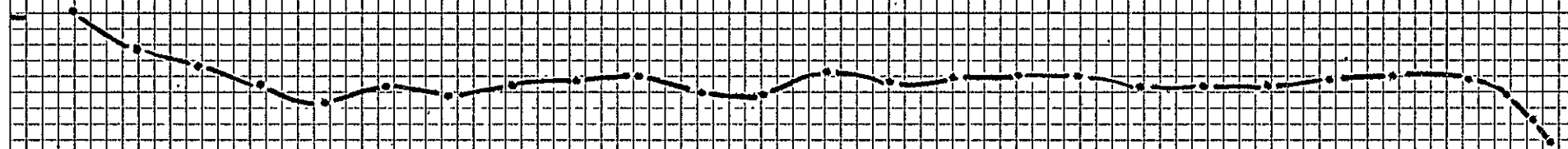
2100

1900

WAVELENGTH (Å)

EUGENE DIETZEN CO.
MADE IN U. S. A.

NO. 341-10 DIETZEN GRAPH PAPER
10 X 10 PER INCH



FLUORITE # 366 a

12-22-65

PERCENT REFLECTANCE

3100

2900

2700

2500

2300

2100

1900

WAVELENGTH (Å)